RECORDS

OF THE

SURVEY OF INDIA

Volume II

1910-11

PREPARED UNDER THE DIRECTION OF

COLONEL S. G. BURRARD, C.S.I., R.E., F.R.S.
Surveyor General of India

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1913

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COLONEL FRANCIS BACON LONGE, C.B., R.E.,

Surveyor General, 1904 – 1911.

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CONTENTS.

PART I.—TOPOGRAPHICAL SURVEY.

REPORTS FROM THE NORTHERN CIRCLE.

REPORTS FROM THE SOUTHERN CIRCLE.

REPORTS FROM THE EASTERN CIRCLE.

PART II.—GEODETIC SURVEY.

PART III.—TRIANGULATION.

PART IV.—TIDAL OPERATIONS.

PART V.—LEVELLING.

PART VI.—MAGNETIC SURVEY.

PART VII.—REPRODUCING OFFICES.

ILLUSTRATIONS.

INDEX MAPS.

(At end of Volume).

APPENDIX.

RECORDS OF
THE SURVEY OF INDIA.

PART I.—TOPOGRAPHICAL SURVEY.

NORTHERN CIRCLE.

(*Vide* Index maps 1 and 6).

Five field parties worked in this circle for the last time; No. 9 Party having now been transferred to the Eastern Circle, all three circles are now composed of four parties each.

During the past field season 27,529 square miles were surveyed consisting of—

15,594	miles of		1-inch		Original survey.
7,259	„	„	1	„	Re-survey.
3,584	„	„	1	„	Supplementary survey.
1,026	„	„	2	„	Survey.
66	„	„	2	„	Re-survey.

The Riverain detachment carried out 436 linear miles of main and 1,984 miles of minor traverse.

The circle remained during the year under the superintendence of Colonel W. J. Bythell, R.E.

No. 1 PARTY (KASHMĪR).

By Major C. H. D. Ryder, D.S.O., R.E.

The head-quarters of the party remained at Srīnagar (Kashmīr) during the summer field season, the area under survey lying entirely in the Jhelum valley in Kashmīr Province of Kashmīr State varying from the level swampy valley to the high ranges of the Pīr Panjāl, Kazināg, etc.

Operations in the field commenced in March 1911 and will continue till middle of October.

During the previous winter the party remained at Mussoorie doing map-drawing.

Personnel.

Imperial Officers.

Major C. H. D. Ryder, D.S.O., R.E., in charge from 10th April 1911.
Brevt.-Major E. T. Rich, R.E., in charge from 8th November 1910 to 9th April 1911.
Lieutenant J. D. Campbell, R.E., in charge up to 7th November 1911.
Lieutenant A. A. Chase, R.E, attached up to 31st December 1910 and from 1st March to 24th September 1911.
Lieutenant K. Mason, R.E., attached from 1st April 1911.

Provincial Officers.

Mr. T. W. Babonau up to 7th November 1910.
Mr. H. H. B. Hanby.
Mr. D. K. Rennick from 13th March 1911.
Mr. R. C. Hanson.
Mr. W. J. B. Miller.
Mr. W. P. Hales up to 2nd March 1911.
Mr. Jiya Lal from 1st November 1910 to 19th May 1911.

Upper Subordinate Service.

Mr. Sher Jang, Khan Bahadur, from 10th December 1910 to 10th September 1911.
Mr. Natha Singh, Rai Sahib.
Mr. Lal Singh, Rai Bahadur, from 1st November 1910.
Mr. Mahindar Singh, Probationer, up to 31st May 1911.
Mr. Muhammad Husain Khan, Probationer, up to 31st May 1911.

Lower Subordinate Service.

25 Surveyors, etc.

Topography.—The area surveyed on the scale of 1 inch =1 mile was 3,514 square miles, the party being divided at first into 3 camps under Lieutenant Chase, Messrs. Hanby and Hanson ; afterwards the latter two alone had camps, there only being 20 plane-tablers at work.

The following sheets were nearly completed and will be finished in October 1911 :—

$43\ \frac{F}{11,\ 12,\ 15,\ 16}$

$43\ \frac{J}{3,\ 4,\ 7,\ 8,\ 11,\ 12,\ 16}$

$43\ \frac{K}{9,\ 13}$

$43\ \frac{N}{4}$

$43\ \frac{O}{1}$

in all 15 sheets. Of these only 10 had been triangulated in advance.

Triangulation.—Lieutenant Mason and Mr. Rennick commenced, and afterwards Lieutenant Chase and Mr. Miller were also started on triangulation, a total area of 3,079 square miles having been completed up to date. Of this 1,829 square miles is in advance for next season.

Fair mapping.—During last winter the following sheets were submitted for publication :—

$43\ \frac{G}{1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8,\ 9,\ 10,\ 11,\ 13,\ 14,\ 15,\ 16}$

$43\ \frac{H}{1,\ 3,\ 6}$

No. 2 PARTY (PUNJAB).

BY BREVET-MAJOR E. T. RICH, R.E.

The head-quarters of the party remained at Siālkot throughout the field season.

PERSONNEL.

Imperial Officers.

Brevet-Major E. T. Rich, R.E., in charge from 15th April 1911.
Captain M. N. MacLeod, R.E., in charge up to 10th March 1911.
Lieutenant J. D. Campbell, R.E., attached from 8th November 1910 to 10th March 1911 and from 15th April to 14th July 1911; in charge from 11th March 1911 to 14th April 1911.
Lieutenant C. M. Thompson, I.A., attached up to 20th March 1911.

Provincial Officers.

Mr. T. W. Babonau from 8th November 1910.
Mr. F. B. Powell.
Mr. W. J. Newland up to 18th April 1911.
Mr. Kanak Singh.
Mr. R. E. Saubolle, from 1st October 1910.
Mr. E. C. O'Sullivan.
Mr. J. McCraken from 9th January 1911.
Mr. Jiya Lal from 20th May 1911.

Upper Subordinate Service.

Mr. Chuni Lal Kapur, Probationer, from 1st October 1910 to 19th August 1911.
Mr. Mahindar Singh, Probationer, from 1st June 1911.

Lower Subordinate Service.

42 Surveyors, etc.

The area under survey lay in the Attock, Jhelum, Shāhpur, Gujrānwāla, Gujrāt and Siālkot districts of the Punjab and in the Native State of Jammu.

The country under survey in the Attock and Jhelum districts comprised part of the salt range and was hilly, interspersed with deep ravines.

The country over the remaining area surveyed consisted of dead level plain intersected by the Jhelum, Chenāb and Rāvi rivers and numerous irrigation canals.

Operations in the field commenced in the beginning of November 1910 and the Party returned to recess quarters at Mussoorie at the end of April 1911.

Topography.—The area surveyed on the two-inch scale was 1,026 square miles and on the one-inch scale 4,971 square miles or a total area of 5,997 square miles.

The Party was divided into six camps under Lieutenant Thompson and Messrs. Babonau, Newland, Kanak Singh, Saubolle and O'Sullivan.

In the middle of January Mr. Babonau was sent back to Mussoorie to the drawing section and Mr McCraken, who had just joined the Party, took over his camp.

The survey was based on triangulation completed by No. 4 Party during 1909-10, and on old traverses done in previous years by No. 1 Party. In parts of two sheets, however, ($43\frac{D}{12,16}$), there were not sufficient points, so a supplementary traverse had to be undertaken in these sheets by Lieutenant Campbell and Surveyor Anwar Ali.

This work took 1½ months to complete and covered an area of 71 square miles. The village maps of the various districts falling in the area to be surveyed were obtained from the Deputy Commissioners. They were pantographed down to the scales of survey and were then given to the surveyors who transferred the detail on to their boards, making each village fit with its plotted trijunctions.

In some districts the detail on these village maps was found very accurate and a great help to the surveyor, in others the detail was so incorrect that it was of no help at all.

A report on these village maps was sent to the Revenue Commissioner of the Punjab who had asked us to let him know as to their accuracy.

The following sheets were completed on the two-inch scale $43\frac{D}{5,9,13}$ and parts of $43\frac{D}{10,14}$, while on the 1-inch scale $43\frac{D}{8,11,12,15,16}$, $43\frac{H}{3,4,7,8,11,12}$, $43\frac{L}{2,6,7,8,11,12,15,16}$, and parts of $43\frac{D}{10,14}$ were surveyed.

Fair mapping.—Sheets Nos. $43\frac{L}{6,7,8,12,16}$ and $43\frac{H}{7,11}$ have been submitted for publication during the year and the remaining 17 sheets are practically completed and will be submitted before the party takes the field.

No. 3 PARTY (PUNJAB).

BY CAPTAIN A. A. MCHARG, R.E.

PERSONNEL.

Imperial Officers.

Captain A. A. McHarg, R.E., in charge.
Lieutenant A. A. Chase, R.E., attached from 1st January to 28th February 1911.
Lieutenant R. S. Wahab, I.A.

Provincial Officers.

Mr. B. M. Berrill.
Mr. A. C. Bose.
Mr. P. A. T. Kenny.
Mr. H. C. W. Stotesbury.
Mr. B. C. Newland.
Mr. F. H. Grant.
Mr. F. J. Grice.
Mr. J. A. Calvert.

Upper Subordinate Service.

Mr. Muhammad Lutf Ali, Probationer.

Lower Subordinate Service.

44 Surveyors, etc.

The field office opened at Delhi in the Punjab on the 1st of November 1910 and closed on the 20th of April 1911.

Recess work started in Mussoorie on the 24th of April 1911.

The outturn of the party for the season is as follows :—

1-inch revision survey.	5955·227 sq. miles.
2-inch revision survey.	65·334 „
1-inch supplementary survey.	262·000 „
Total	6282·561 sq. miles.

This includes the sixteen standard sheets falling in degree sheet 53 H and the eight in the western half of degree sheet 53 L, or a total of twenty-four standard sheets. The two-inch survey comprised Delhi and the country in its immediate vicinity as far south as the Kutb. This area was surveyed on a

large scale owing to the difficulty of showing with any degree of accuracy all the places of archæological interest and the suburbs of Delhi, on a small scale.

Triangulation.—An area of 325 square miles was triangulated. This triangulation was supplementary to that previously existing and was only required for obtaining heights over the Ballabgarh hills.

All the 24 standard sheets surveyed during the year will be drawn and forwarded to the Superintendent, Northern Circle, for submission to the reproducing offices by about the end of November 1911.

A guide map of Delhi and vicinity has also been drawn and will be submitted in due course.

The country surveyed comprised parts of the Delhi and Gurgaon districts of the Punjab and parts of the Meerut, Alīgarh, Morádábád and Budaun and the whole of the Bulandshahr districts of the United Provinces.

With the exception of the ridge at Delhi and its continuation to the south in the Delhi and Gurgaon districts, the whole of the country was flat. The country between the Jumna and Ganges rivers is much cut up by canals. The slope of the ground which is roughly about 18 inches to the mile falls from north-west to south-east.

With the exception of the hilly portions of the country surveyed and the Jumna and Ganges khadars the whole area is practically under cultivation. The average height of the flat area is about 650 feet above sea level.

None of the area surveyed is particularly well wooded; but in all the districts of the United Provinces mango and fruit groves are more or less common.

The work consisted chiefly of revision survey and a small amount of supplementary survey.

Blue prints of the last published 1-inch maps were used in every case except for the 2-inch work in standard sheet 53 $\frac{H}{2}$ and for the hilly portion of ground in 53 $\frac{H}{3}$ for which an "aluminium mounted" board was used and on to which the outline from the old work was transferred in blue.

This aluminium mounted board was found very satisfactory and the distortion of the paper was very small indeed; but as blue prints are already distorted, before they are mounted, aluminium plates for revision and supplementary work are useless.

All the blue prints supplied from the map publication office were in new standard sheet sizes, and the extra strip of 2′ 27″ had to be super-imprinted on to the adjoining old eastern standard sheets.

Owing to the old sheets being unequally distorted, a certain amount of difficulty was found in making the two sheets fit together correctly, but the majority were extremely good and it was only in one case that the surveyor found the trijunctions east and west of the joining line to disagree *inter se*.

Some blue prints unfortunately were received with no trijunctions on them. The trijunctions were therefore plotted, but owing to the distortion of the paper, and also to the original traverse work not having been sufficiently connected with G. T. points, it was found very difficult to plot these trijunctions in their correct positions. In most cases these plotted trijunctions had to be rejected, and the survey was carried out by making fixings from recognisable points. It is most important for this sort of revision and supplementary work that blue print should have all the trijunctions on them.

No. 4 PARTY (UNITED PROVINCES).

By Captain L. C. Thuillier, I.A.

PERSONNEL.

Imperial Officers.

Captain L. C. Thuillier, I.A., in charge.
Lieutenant F. B. Scott, I.A.

Provincial Officers.

Mr. G. J. S. Rae.
Mr. H. W. Biggie.
Mr. C. E. C. French.
Mr. A. B. Hunter.
Mr. G. E. R. Cooper.
Mr. F. E. R. Calvert.
Mr. Moqimuddin.

Upper Subordinate Service.

Mr. Vidya Nath Suri, Probationer.

Lower Subordinate Service.

69 Surveyors, etc.

The field head-quarters of the Party opened at Lucknow on the 17th of October and remained there throughout the field season. The recess quarters continued at Mussoorie.

Topography.—The area for survey lay in the districts of Lucknow, Unao, Cawnpore, and Etāwah; and portions of districts Hardoī, Rāe Barelī, Farrukhābād, Mainpurī, Agra, Hamīrpur, Jālaun and Gwalior State.

The area surveyed on the 1-inch scale was 4,933 square miles new survey and 1,115 square miles supplementary survey.

The sheets surveyed were 54 $\frac{J}{13}$, 54 $\frac{N}{1, 2, 3, 5, 6, 7, 9, 10, 13, 14}$, 63 $\frac{B}{1, 2, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16}$ and small areas in 63 $\frac{B}{3, 4, 7, 8}$. Portions of some of these sheets needed supplementary survey only.

Field work continued till the second week in April when the party proceeded to recess quarters except a few surveyors who completed later.

The work this season was entirely new to the majority of the surveyors. The country being flat and covered with high crops, and enclosed by groves of trees, it was found impossible to plane-table by interpolation only, and chain traverse had to be resorted to.

Three large rivers ran through portions of the work, *viz.*, the Ganges, the Jumna and the Chambal; and the country was intersected by numerous smaller rivers and streams. Near the Jumna and Chambal rivers the country was cut up by deep ravines. These two rivers flow in very deep beds, in places 150 feet or more below the surrounding plains.

Traversing.—The area traversed comprised a portion of the Lucknow, Bāra Bankī, and Partābgarh districts and the whole of the Rāe Barelī, Sultānpur and Fyzābād, in sheets 63 F, 63 $\frac{J}{2, 3, 4, 6, 7, 8}$, 63 $\frac{G}{5, 9, 13}$. The country was similar to last year, perfectly flat, well cultivated, and in parts covered with groves, and covered an area of 6,236 square miles.

Traverse lines were run along graticules of half standard sheets, picking up trijunction pillars, and intersecting trees and all conspicuous objects. Connections were made with 21 G. T. stations. The average daily outturn per man was 8 angles and 136 chains per working day.

This detachment having completed its work has been broken up.

Cantonment Surveys.—The following cantonments were surveyed during the year under report: Dargai, Malakand, Chakdarra, Hyderābād (Sind) and Loralai, and alterations and additions were made to the previous editions of the maps of Risalpur and Allahābād.

Maps of 8 cantonments were sent for publications, *viz.*, Dum-Dum, Meerut, Lucknow, Fort Sandeman, Dargai, Malakand, Chakdarra, and Allahābād.

The total cost of the section was Rs. 13,000 and the outturns and cost rates are as follows:—

Triangulation	. . .	3,582 acres at Rs.	0·75 per acre.
Traversing	. . . .	10,153 „ „ „	0·35 „ „
Detail survey 16"	. .	10,153 „ „ „	0·29 „ „
„ „ 64"	. .	92 „ „ „	1·86 „ „
Mapping 16"	. .	6,300 „ „ „	0·51 „ „
„ 64"	. .	100 „ „ „	3·75 „ „

Average outturn per working day per man—

Traversing 11 angles	100 chains.
Detail 16" including contouring . . .	24·7 acres.
„ 64" „	1·4 „

No. 9 PARTY (PUNJAB).

BY MAJOR G. A. BEAZELEY, R.E.

Work in Baluchistān having been completed, the Party took up work in the Punjab in degree sheets 39M, 44A, and E, in continuation of the work of No. 3 Party.

PERSONNEL.

Imperial Officers.

Major G. A. Beazeley, R.E., in charge.

Provincial Officers.

Mr. J. A. Freeman.
Mr. W. J. Newland.
Mr. Dhani Ram.
Mr. P. A. T. Kenny.
Mr. H. C. W. Stotesbury.
Mr. D. K. Rennick.
Mr. J. McCraken.
Mr. A. K. Mitra.
Mr. A. J. A. Drake.
Mr. Abdul Aziz.
Mr. H. H. P. Butterfield.
Mr. F. Byrne.
Mr. F. J. Grice.
Mr. W. P. Hales.

Upper Subordinate Service.

Mr. Gopal Singh, Rai Bahadur.
Mr. Dalbir Rai.

Lower Subordinate Service.

60 Surveyors, etc.

In all 5,687 square miles were surveyed on the 1-inch scale in the districts of Jhang, Miānwāli, Shāhpur, Lyallpur, Gujrānwāla, Lahore and Montgomery; of this area 2,176 square miles was new survey, 1,304 square miles was re-survey and 2,207 supplementary survey; the field head-quarters being at Lyallpur. The party was transferred to the Eastern Circle from the 1st of April 1911, but continued to work in the Punjab till it had completed its programme.

Triangulation and a small amount of traverse work was taken up in Chotā Nāgpur in view of next field season's programme. The country surveyed was absolutely flat, but differed considerably in other respects from the dreary country west of the Jhelum. This consisted of rolling sand-hills covered with scanty scrub and a few stunted trees, while the Chenāb Colony in the Lyallpur district is fertile, well watered, and closely cultivated. The country in Jhang falls midway between these two classes.

The Chenāb Colony is well timbered and the trees obstruct the view a good deal in consequence. The "square" system of irrigation gives a very curious appearance to the field sheets, as all the field distributaries and villages are laid out in squares and give a chess-board appearance to the maps.

Recess duties.—An arrears mapping section was maintained at Mussoorie and is still continuing its labours. Mr. Hales opened the recess office at Shillong about the middle of May and held charge till the officer in charge arrived on 1st of August after a very protracted field season. Sheets $39\frac{M}{9,13,14}$, $44\frac{A}{1,2,4,12}$, $44\frac{E}{1,2,3,4,11,12,13,15}$ are all nearly completed.

It is proposed to close the mapping section at Shillong by the end of December 1911 and send all work which cannot be completed to the Northern Circle drawing office to be finished there. Owing to lack of good draftsmen

and sickness amongst the men in Shillong, the progress of mapping has been rather slow.

To carry out revision and supplementary survey work to the best advantage as regards outturn, quality and cheapness of cost, it is essential that the field sections should be complete in every respect before the party takes the field; and the pantograph detachments should be sent down early in the recess to the head-quarters of the districts in whose area the work for the following field season falls, and these detachments inspected at least once by the officer in charge of the party.

The officers in charge of these detachments should receive preliminary training in pantograph work beforehand to ensure their thoroughly understanding exactly what is required of them, so that they may employ the men under them to the best advantage. This preliminary instruction can easily be arranged for before the close of the field season if suitable arrangements are made.

In some cases much labour may be saved by utilising the 4-inch reductions made by the local authorities and adding all detail omitted by means of a special gridiron on tracing paper showing the squares on the full size village maps on the 4-inch scale; this gridiron often allows of the additional detail being drawn in by eye on the 4-inch reductions. The latter generally so the village site, principal roads, railways and canals, and this facilitates all subsidiary detail being put in by eye; by this means a trained pantograph detachment can reduce about 30 villages a day instead of only about 3. This was the outtuin of the detachments at Lyallpur and Gujrānwāla after a month's practice.

The pantograph detachments should be organised as follows:—One provincial officer should be in charge and under him should be 3 surveyors capable of managing a pantograph; two of these pantographs should be $2\frac{1}{2}'$ and one $3\frac{1}{2}'$ or $4\frac{1}{2}'$; 3 more surveyors should be employed in inking up the reductions in the correct colours and symbols, and three more should be employed in transferring these to the field sheets and inking them up.

With regard to the latter it was found a good plan to ink these up straight away in the correct colour; one objection was raised to this, it being pointed out that it would lead to surveyors scamping their work; but this was not found to be the case. The advantages of inking up are two,—*viz.* (*a*) the paper is in good condition and the inking up can be done much neater and finer; (*b*) the surveyor knows exactly what the detail represents and does not run the risk of confusing roads with canals, etc. The colours used may be lighter than usual if considered necessary, leaving it to the surveyor to colour up darker all detail found correct on the ground.

RIVERAIN DETACHMENT.

By Mr. Maya Das Puri.

The field season commenced on 1st October 1910 with head-quarters at Wazīrābād and continued till the middle of April when the Party went to Lahore for recess.

Personnel.

Provincial Officers.

Mr. Maya Das Puri, in charge.
Mr. Moqimuddin.

Upper Subordinate Service.

Mr. Chuni Lal Kapur, Probationer, from 20th August 1911.

Lower Subordinate Service.

75 Surveyors, etc.

The riverain area was as usual broken, shrubby, marshy, and sandy. Portions of villages situated above the high bank were well cultivated.

The Lower Bāri Doāb tract was plain, full of reserve forests, unpopulated and mostly waterless.

During recess the 4-inch compilation of riverain boundaries, traces for the settlement department, completion of computations, and drawing up instructions and various forms of return for the Lower Bāri Doāb work, were carried out.

The procedure adopted for the *riverain work* was the same as reported last year. The original programme was considerably modified by the civil authorities. All minor traverses for the cadastral surveys were finished by end of February 1911, and 2,178 plotted and compiled "Masairs" (settlement mapping sheets) were supplied to the settlement officers concerned in time to enable them to complete their records before the rise of water. Base lines with permanent mark stones were fixed on both banks of the rivers about one mile apart for the future survey and demarcation of riverain boundaries.

Lower Bāri Doāb.—Work was undertaken during February 1911 at the special request of the Punjab Government. The settlement staff was deputed by the 1st Financial Commissioner to do the work, and in addition several professional hands were employed.

All of them had to be trained for a considerable time.

The men were made to work from the whole to the part, allowing a maximum error of 1 in 500. Big blocks of about 80 to 100 rectangles were first broken, and the patwaris had to work inside these.

Dera Ismail Khān.—A special Indus survey (scale 4 inches = 1 mile) was undertaken during September 1910 at the request of the Assistant Commanding Royal Engineer, Dera Ismail Khān, and was completed on the 22nd of October with great difficulty.

The following table shows the work done during the field season:—

Class of work.	Locality.	MAIN CIRCUITS.			MINOR TRAVERSES.				BASE LINES OR RECTANGLES.		
		Square miles.	Linear miles.	Stations.	Square miles.	Linear miles.	Stations.	Village.	No. of corners.	No. of squares.	Area.
Traversing for 4-inch Compilation of Riverain boundaries.	River Jumna (Districts Sahāranpur and Ambāla) Indus (D. I. Khān and Miānwāli).	101	87·13	159	...	107·28	187	...	...	...	...
Minor traversing for cadastral surveys. Scales 24 inches and 26·4 inches = 1 mile.	Chenāb (Gujrānwāla), Beās (Hoshiārpur) Sutlej (Ferozepur)	388	348·68	563	320	1,629·89	708·1	259	456	152	139·91
Dera Ismail Khān Indus special survey. Scale 4 inches = 1 mile.	River Indus. Districts D. I. Khān and Miānwāli.	...	...	...	53	106·91	199	...	...	...	...
Lower Bāri Doāb 25 acres. Rectangular survey	Area commanded by the Lower Bāri Doāb canal (Montgomery).	...	...	...	...	140	708	...	...	416·4	...
		489	435·81	722	373	1,844·08 Riverain 140·0 Lower Bāri Doāb	741·7 Riverain 708 Lower Bāri Doāb	259	456	152 Riverain 416·4 Bāri Doāb	139·91

The total expenditure of the detachment was Rs. 73,091.

SOUTHERN CIRCLE.

(*Vide* Index maps 2 and 7).

Lieutenant-Colonel P. J. Gordon, I.A., was in charge from 24th March till 22nd September 1911 and Brevet-Colonel T. F. B. Renny-Tailyour, C.S.I., R.E., for the remainder of the year.

Thirteen thousand one hundred and seventy-one square miles were surveyed during the year under report; the smallness in outturn is principally due to No. 8 Party which only surveyed 1,287 square miles in the season, owing to the abnormal difficulty of the country in which it was working.

The following is the detail of the country surveyed :—

4,741	miles	of	1-inch	New survey.
5,472	"	"	1 "	Revision survey.
2,010	"	"	1½ "	Survey.
393	"	"	2 "	"
555	"	"	2 "	Revision survey.

A new departure was the introduction of 1½-inch survey for country which was too intricate to be shown on the 1-inch. It proved very successful, and as may be seen from the table on page 23, the cost-rate comes to very little more than the 1-inch.

No. 5 PARTY (CENTRAL PROVINCES).

BY MAJOR C. L. ROBERTSON, C.M.G., R.E.

The field head-quarters of the party were located at Pachmarhī as being fairly centrally situated, and as having a sub-treasury through which funds were procurable.

As it was impossible to obtain any godown in Pachmarhī to store the party equipment during recess, it was decided to re-assemble the party at the close of the field season at Jubbulpore and store the property there as had been done during the last two field seasons.

PERSONNEL.

Imperial Officers.

Major C. L. Robertson, C.M.G., R.E., in charge.
Lieutenant C. F. Nation, R.E.

Provincial Officers.

Mr. F. P. Walsh.
Mr. C. Litchfield.
Mr. S. S. McA'Fee Fielding.
Mr. C. West.
Mr. Munshi Lal.
Mr. F. C. Pilcher.
Mr. E. J. Hanby.
Mr. F. C. Saint.

Upper Subordinate Service.

Mr. Eknath Battu.

Lower Subordinate Service.

32 Surveyors, etc.

Topography.—To execute the detail surveys on the 1-inch and 1½-inch scales, the party was divided into three camps, each under an officer of the Provincial Service. 1,373 miles were surveyed on 1½-inch scale comprising sheets $55\frac{I}{14, 15, 16}$, $55\frac{M}{4}$ and parts of $55\frac{M}{6, 7, 8}$ in districts Narsinghpur, Saugor, Damoh, and Jubbulpore.

The 1-inch work comprised sheets $55\frac{J}{1, 5}$ and parts of $55\frac{J}{2, 6}$ in Hoshangābād and portion of Bhopāl State.

The Revision Survey work was over such a large area and so far removed from most of the other work, that it was found impossible to require the officers in charge of other camps to supervise it. It was therefore carried out practically without supervision, directly under the control of the officer in charge of

the Party. The best and most trustworthy surveyors were selected, and were given full instructions as to what was required of them before proceeding to the ground. Sheets $55\,\frac{\mathrm{I}}{9,\,13}$, $55\,\frac{\mathrm{M}}{10,\,11,\,12,\,14,\,15,\,16}$, $55\,\frac{\mathrm{N}}{9,\,13}$, and parts of $64\,\frac{\mathrm{A}}{3}$ were dealt with in this manner.

The Quarter Master General of India having asked for a survey on the scale of 6 inches=1 mile, of the fields and fallow lands of Saugor Cantonment, the ground was examined with a view to commencing this work. It was then found that the traverse stations on which the existing cantonment survey had been based some 45 years ago, had disappeared, and as there were no other fixed points on which the survey could be based, it had to be abandoned for the season.

The country surveyed comprised a section of the valley of the Narbadā River and the hills to the north and south of it. For a width of some 10 or 15 miles each side of the river, there is a flat plain about 1,000 feet above sea level, mostly cultivated and covered with scattered trees. The hills to the north of this are more or less wooded, and rarely reach an altitude of 2,000 feet; on the south side of the valley, however, they rise some 1,000—1,500 feet higher, culminating in the Dhūpgarh peak, 4,500 feet, on the Pachmarhī plateau. Here the forest is dense and the slopes steep, being scored in all directions with precipitous chasms 200 or 300 feet deep.

Triangulation.—The proposed programme was to complete net work triangulation in degree sheets 55 I and J. For this purpose the triangulating strength of the Party was fixed at 2 provincial officers, 1 upper subordinate and 1 surveyor; though it was anticipated that it would not be necessary to maintain this strength throughout the field season. Owing to the slowness of two of the observers, this programme was not carried out; and the result of the season's work is that out of 14 standard sheet areas proposed for survey, 6 remain untriangulated.

Recess duties.—The Party returned from the field with 19 sheets ready for drawing—this number was however more than the drawing strength of the Party could possibly deal with, and 4 Revision Sheets were handed over to the circle drawing office. Owing to the lack of good draftsmen, the progress of the remaining 15 sheets was very slow, and it is unlikely that more than half will be completed before the close of the recess season.

The computation of the triangulation is complete.

This year, for the first time, the Party went through the field season without having a hospital assistant attached, and there is no reason to suppose that the general health has suffered in consequence. On going into the field the position of the nearest dispensary was pointed out to each man; but in practice these dispensaries were so far apart as to be useless. The men were therefore dependent on their medicine boxes, which proved both in the nature and quantities of the drugs they contain, most ill-adapted to their purpose. Next season a special selection of drugs will be packed in a box made for the purpose under party arrangements.

With reference to the out-turns (shown in Table I on page 21) it is interesting to note that the average plane-tabler works nearly as quickly on the $1\frac{1}{2}$-inch scale as he does on the 1-inch scale. This perhaps is not at once apparent till the fact that nearly all the work done on the 1-inch scale, and classed as survey, lay in the plain of the Narbadā, in a country which was undoubtedly much easier of survey than the average of that done on the $1\frac{1}{2}$-inch scale.

No. 6 PARTY (BERĀR).

BY LIEUTENANT K. W. PYE, R.E.

The field season opened at Chānda on the 1st of November 1910, and closed on the 25th April 1911; the Party office reopening for the recess season at Bangalore on the 1st of May.

PERSONNEL.

Imperial Officers.

Captain H. Wood, R.E., in charge up to 21st April 1911.
Lieutenant A. H. Gwyn, I.A., in charge from 22nd April 1911.
Captain F. F. Hunter, I.A., in charge from 17th May 1911.
Lieutenant K. W. Pye, R.E., in charge from 14th August 1911.

Provincial Officers.

Mr. Amar Singh.
Mr. J. H. S. Wilson.
Mr. P. K. Anderson.
Mr. E. A. Meyer.
Mr. F. B. Kitchen.
Mr. R. B. Gildes.
Mr. J. O'C. Fitzpatrick.
Mr. A. J. Moore.

Upper Subordinate Service.

Mr. Dharmu.

Lower Subordinate Service.

41 Surveyors, etc.

The field work carried out during the year was as follows:—

(*i*) Survey on the 2-inch scale of reserved forests falling in the standard sheets 55 $\frac{L}{11,15,16}$, 55 $\frac{P}{4}$, 56 $\frac{M}{1}$, 56 $\frac{I}{13}$ and part of 56 $\frac{I}{9}$ amounting to 97 square miles.

(*ii*) Revision survey on the 1-inch scale of portions of sheets 46 $\frac{P}{2,3,6}$, 55 $\frac{P}{4}$ 56 $\frac{M}{1}$, amounting to 770 square miles.

(*iii*) Survey on the 1-inch scale of remainder of sheets 46 $\frac{P}{2,3,6,12,15,16}$, 55 $\frac{L}{11,15,16}$, 55 $\frac{P}{4}$, 56 $\frac{M}{\ }$, 56 $\frac{I}{13}$, totalling 2,223 square miles.

(*iv*) Triangulation of standard sheets 56 $\frac{E}{1 \text{ to } 8 \text{ and } 12, 15, 16}$ and 56 $\frac{I}{3}$.

(*v*) Theodolite traversing of boundaries of reserved forests falling in sheets 55 $\frac{L}{16}$, 56 $\frac{M}{1}$, 56 $\frac{I}{1, 5, 9, 13}$, and 56 $\frac{E}{13}$, and also the boundary of Santá Cruz Cant ent, Bombay.

The work lay in the following districts:—

Bombay.—East Khāndesh.

Hyderābād.—Aurangābād, Adilābād, Parbhani.

Central Provinces.—Wardhā, Chānda.

Berār.—Yeotmāl, Akola.

The surveyors were divided into 3 camps under the late Sirdar Amar Singh, and Messrs. Wilson and Kitchen. The traverse camp was under Mr. Meyer, and was occupied exclusively with traversing the boundaries of reserved forests in Berār, falling in the programme of the season under report and a portion of the next season. At the end of the season, the traversing of Santa Cruz Cantonment was taken up, the survey of which will be done during the coming season.

The country under survey was of a varied nature. The reserved forests surveyed on the 2-inch scale, and a certain proportion of the 1-inch work (principally in the Southern sheets) were densely wooded and difficult to survey. On the other hand there were large areas of open undulating country where work progressed rapidly.

The country under triangulation varied from hilly to undulating; it was on the whole open, and not much clearing was necessary.

During recess the party completed the mapping of the 12 sheets surveyed during the field season.

In addition the following were also completed :—

(1) Computations of triangulation of sheets 56 $\frac{F}{1, 2, 5, 6}$ and in 8 more sheets the computations partially finished.

(2) Computations of traverse work falling in 56 $\frac{E}{13}$ and 56 $\frac{I}{1, 5, 9}$ and the plotting of 4 inch forest boundary traces of 56 $\frac{E}{13}$ and 56 $\frac{I}{1}$.

(3) The completion of rough charts and manuscript tables of data for degree triangulation charts 55 H and L.

No. 7 PARTY (MADRAS).

BY MR. W. M. GORMAN.

PERSONNEL.

Imperial Officers.

Captain C. P. Gunter, R.E., in charge from 30th December 1910.
Lieutenant A. H. Gwyn, I.A., in charge up to 29th December 1910.

Provincial Officers.

Mr. W. M. Gorman.
Mr. J. O'B. Donaghey.
Mr. H. D. W. Stotesbury.
Mr. A. K. Mitra.
Mr. H. H. P. Butterfield.
Mr. J. C. St. C. Pollett.

Upper Subordinate Service.

Mr. Abdul Hakk.

Lower Subordinate Service.

26 Surveyors, etc.

The Party worked this year on the 1-inch and 1½-inch scales in the low country in the South Kanara District of the Madras Presidency, north of Mangalore, and a portion of North Kanara in Bombay. 1-inch Revision Survey of Forest reserves was carried out in South Kanara and 2-inch Revision in Coorg.

The triangulation in advance of Survey was situated in the Coimbatore and Salem districts. The following sheets were completely surveyed, *viz.*, 48 $\frac{K}{9, 10, 11, 12, 13, 14, 15, 16}$, 48 $\frac{O}{2, 3, 4, 8, 12}$ and part of 48 $\frac{L}{13}$ and 48 $\frac{P}{11, 16}$ revised. Triangulation was carried out in 10 sheets of 57 H.

The country under survey comprised every variety, ranging from the open and bold hilly country of Mysore which was ideal for plane-tabling, to the lowlying and intricate ground of South Kanara. It may be described as a succession of highly cultivated valleys, covered with belts of jungle 10 to 20 chains in width, fringing the cultivated areas, and dotted with innumerable isolated huts. There are no village sites, except the towns along the main roads.

Distinguishable land-marks which were of use to surveyors were Mount Kudremukh, 6,207 feet above sea level and the Jamālābād Fort hill which has a 1,000 feet sheer drop of smooth granite beneath it. The Gomata Rāya at Kārkala—a rock statue 41 feet high—was also used as a trigonometrical point.

The revision of the 1-inch Mysore topographical work was done the same as last year, by transferring the old work from black prints on tracing paper as the work progressed. That of the 4-inch Forest Surveys was done by transferring piece-meal the 1-inch reductions of the original 4-inch survey on to the plane-tables. The original work of both of these surveys was found very good.

In South Kanara the survey was greatly facilitated by the 1-inch village plots compiled specially by the Madras Revenue Survey. These consisted of skeleton maps drawn in 1-inch standard sheets with village and traverse trijunctions plotted, as well as any Survey of India trigonometrical stations that existed when the Revenue Survey was done. The position of most of these trijunctions agreed with the plane-table work ; any discrepancy was

usually due to the actual site of the trijunction being doubtful. These skeleton maps also gave the very greatest assistance in the correct spelling and identification of village names. Next year it is hoped that these maps will contain in addition Forest boundaries, roads, cultivation limits, streams that have been traversed, and other detail taken up by the Revenue Survey.

The field head-quarters of the party was in Mangalore, and the recess office closed in Bangalore on 7th November and reopened there on 9th of June; thus giving a field season of 7 months.

Recess duties.—It is hoped that twelve out of the thirteen completely surveyed sheets will be fair mapped by the end of recess; 48 $\frac{K}{13}$ being left as arrears.

An index degree map on the $\frac{1}{4}$-inch scale of 57 H is under preparation and will be sent to be vandyked as soon as completed.

The arrears of triangulation charts have been partly disposed of by transferring some of them to the Superintendent, Trigonometrical Surveys, and to No. 11 Party. The computations of this season's triangulation have been completed.

No. 8 PARTY (MADRAS).

BY CAPTAIN C. M. BROWNE, D.S.O., R.E.

PERSONNEL.

Imperial Officers.

Captain C. M. Browne, D.S.O., R.E., in charge from 16th June 1911.
Lieutenant S. W. S. Hamilton, R.E., in charge up to 15th June 1911.
Lieutenant C. G. Lewis, R.E.

Provincial Officers.

Mr. W. F. E. Adams.
Mr. E. J. Biggie.
Mr. S. F. Norman.
Mr. M. Mahadeva Mudaliar.
Mr. C. O. Picard.
Mr. Balaji Dhondiba.
Mr. M. S. Ganesa Aiyar.

Upper Subordinate Service.

Mr. Anantrao Dhondiba.

Lower Subordinate Service.

20 Surveyors, etc.

The operations of the party were carried out in parts of the Malabar district of the Madras Presidency, and in the Native States of Travancore and Cochin. The work in Travancore included the survey on the 2-inch scale of the Periyār catchment area and the commencement of the survey of the Pambiyār catchment area. Detail survey was carried out in sheets 58 $\frac{B}{3, 4, 7, 8, 11}$ and such portions of 58 $\frac{G}{2, 3, 6, 7}$ as were included in the Periyār catchment area. Traversing was carried out in the Periyār and along the backwater of the coast, and triangulation in sheet 58 $\frac{G}{3}$.

The Party left Bangalore on the 7th of November for the field head-quarters at Pīrmed and was delayed on the road for nine days by the Theni river being in flood and impassable.

Recess quarters were re-opened at Bangalore on the 21st of June.

Nature of the country.—The Periyār catchment area forms a part of the unexplored portions of the Pandalam hills; it is for the most part covered with evergreen forest and dense undergrowth; there are little or no means of communication, and transport and labour are extremely difficult to obtain. The few hill men obtainable had to be employed for the surveyors and as supplies had to be imported causing great delay, the triangulator had a difficult time.

The outturn of survey is small and the rates high, the cause being the extraordinary difficulty of the country surveyed, which either consisted of dense forest, or else of paddy and cocoanut country studded with innumerable habitations.

Survey methods.—As it has been found impossible to show all the intricate detail on the coast on the 1-inch scale, one sheet $58\frac{B}{4}$ was surveyed on the $1\frac{1}{2}$-inch scale as a trial. The experiment has proved that this scale is the most suitable; the cost-rate is but a little more than the 1-inch while at the same time all detail can be shown. In the coming field season, three sheets will be surveyed on this scale.

Plots of all the State and Tâluk boundaries were obtained from the proper authorities in Malabar and Cochin; but in Travancore they do not exist, and the Taluk maps on the scale of 2 inches to one mile together with local information have been taken as the authority.

During the field season experiments were made with special plane-table sections and the following is the brief result of the trials:—

(*i*) *Drawing paper mounted on a thin sheet of aluminium.*—Monthly measurement of the graticules were taken and showed no appreciable differences, but the paper did not lie flat on the aluminium and especially on damp mornings rose up from the metal plate and was not a success.

(*ii*) *Mill-boards.*—These proved no better than paper mounted in ordinary manner, and the ink was very apt to run when the board was damp. As Bristol boards have not been received in time for next season's work, these mill boards will be tried again with sheets of rag litho paper pasted over them to try and exclude the moisture.

(*iii*) *Bristol Boards.*—These were a success and would have been largely employed this season if they had arrived in time. The monthly measurements gave good results and the surface is nice to work on, while they do not seem to be easily affected by the weather.

Recess duties.—On the conclusion of the last survey year, the fair mapping of the party was badly in arrears, 13 sheets being incomplete when the party left for the field.

To cope with this a drawing section was left in Bangalore during the field season, and 7 of these arrears sheets were completed and submitted for publication; one other sheet being drawn in the circle drawing office.

During recess the whole of the arrears and the area newly surveyed were fair drawn with the exception of $58\frac{B}{8,11}$ and a small portion of $58\frac{A}{15}$.

As the sheets will not be submitted for publication in the Survey year under report, a large portion have to be shown as arrears; but as only some 500 square miles remain to be fair mapped, the drawing is in a much better state than the actual figures imply.

EASTERN CIRCLE.

(*Vide* Index maps 3 and 8.)

This circle remained under the superintendence of Brevet-Colonel G. B. Hodgson, I.A., throughout the year.

The circle came into existence on the 1st April 1910, and then consisted of only three Parties, Nos. 10, 11 and 12. No. 9 Party was transferred to the circle from 1st April 1911, but continued to be almost wholly employed on the mapping of its work in the Punjab throughout the year; and a section of the party will remain so employed until the end of December, after which all mapping that remains unfinished, will be transferred to the Northern Circle drawing office.

9,218 square miles were surveyed during the year consisting of—

8,564	miles of	1-inch survey.
445	„	1-inch Supplementary survey.
209	„	2-inch survey.

No. 10 PARTY (UPPER BURMA).

The party assembled for field work at Bhamo on the 18th November 1910, and all surveyors had reached their ground and commenced work by the 25th, and continued to the end of May 1911; the field season having been unduly prolonged because the programme was so far from completion at the usual time for closing field work. The programme was not completed; 3 full sheets and a small part of a fourth being left undone. This was due to the retirement or discharge of five surveyors and the deputation of three more with political missions after the programme had been drawn up.

PERSONNEL.

Imperial Officers.

Captain E. C. Baker, R.E., in charge.
Lieutenant W. E. Perry, R.E.

Provincial Officers.

Mr. O. D. Smart.
Mr. F. S. Bell.
Mr. P. Williams.
Mr. C. S. Littlewood.
Mr. W. G. Jarbo.
Mr. Asmatullah Khan.
Mr. W. H. Strong.
Mr. C. B. Sexton.

Upper Subordinate Service.

Mr. Lachman Daji Jadu, Rai Sahib.
Mr. Hayat Muhammad.
Mr. B. C. H. Collins.

Lower Subordinate Service.

46 Surveyors, etc.

The total area surveyed within the limits of Burma was 2,798 square miles of which 2,615 were surveyed on the 1-inch, and 183 square miles consisting of forest surveys, on the 2-inch scale. An area of 290 square miles was sketched beyond the frontier on the 1-inch scale, and reconnaissance surveys were carried out by three Surveyors attached to political missions known as the Hpimma and Makware missions. The former surveyed an area of 1,890 square miles on the ½-inch, 4 square miles on the 4-inch and 2½ square miles on the 6-inch scale, and the latter 1,845 square miles on the ¼-inch scale.

Triangulation.—The triangulation was carried out by one Provincial officer and the traversing by three traversers who also carried out the traversing of

forest boundaries. The triangulation was connected with the Upper Irrawaddy Secondary Series, emanating from the Great Salween Series and running northwards between the meridians 97° and 98°, which was being observed during the season under report.

Nature of country.—The country under survey fell almost entirely in the Bhamo district, but included in the south a very small part of Möngmit State and a small portion of Myitkyinā district in the north-east. To the east of Bhamo there is a strip of flat country about 13 miles wide and beyond that broken, heavily wooded hills. The south-eastern portion of the work was also hilly and wooded; but although attaining in places a height of 8,000 feet above the sea, this part was the easiest to survey. The valleys of the Irrawaddy and Taping rivers were in parts marshy and covered with thick jungle. Roads and paths were fairly plentiful excepting to the west of the Irrawaddy.

The cost-rates for the detail survey are much higher than those of last season which is due to the appointment to the party of a second Imperial officer who was employed on 1-inch plane-tabling; and in the case of the 2-inch forest survey, to the fact that the survey of a similar nature done last season was revision work.

Forest survey.—The following forest reserves fell into the area under survey, and not having been previously surveyed were mapped on the 2-inch scale:—Taungbalaung of the Myitkyinā division and Bumsawn, Teinthaw, Momauk, Sinlum, Lungja, Kadawtaung, Si-u, Namik and Namkao of the Bhamo division; also the forests of Naunghu and Namme of the latter division which it is proposed to reserve. The reserves of Simaw, Munsin, Nanhan, Mohlaing and Mosit had been previously surveyed. The survey of the Namme reserve was not completed, but will be done next season when the survey of all the forests in the Bhamo division will have been done. No 4-inch boundary surveys were done this season.

Recess work.—The mapping was well advanced at the close of the season, and it is expected that it will be completed before the party takes the field again: 13 sheets were completely surveyed and mapped, *viz.*, Nos. 92 $\frac{H}{2, 3, 4, 6, 7, 8, 10, 11, 12, 15, 16}$ and 93 $\frac{E}{2, 5}$.

The $\frac{1}{4}$-inch reconnaissance survey done by R. S. Lachman Jadu while attached to the Makware mission, and that drawn by Captain Cotter who worked from the Assam side, was fair drawn for inclusion in sheets 14 S. E. and 15 N. E. of the S. E. Transfrontier Series. The $\frac{1}{4}$-inch survey done by Mr. Hayat Muhammad and Surveyor Sheikh Muhammad Salik with the Hpinma mission was sent to the Simla drawing office for fair mapping.

Three triangulation charts of sheets 84 M, 93 A and 93 E, which were reported as in hand last season, were completed, while those of 92 L and 93 I are now in hand and will be completed next season after which no more charts will be drawn by the party.

Cantonment surveys.—The survey of the cantonment of Rangoon was completed and also the mapping, which, together with that of the cantonments of Bhamo, Mandalay, Maymyo, and Meiktila, and of the remaining bazars of Secunderābād and Bolārum, was forwarded to the Trigonometrical Office for publication.

This section was disbanded in May 1911 having completed the survey and mapping of all the cantonments allotted to it.

No. 11 PARTY (KARENNI AND SOUTHERN SHAN STATES).

PERSONNEL.

Imperial Officers.

Captain R. H. Phillimore, R.E., in charge from 27th November 1910.
Lieutenant J. A. Field, R.E., in charge up to 26th November 1910.

Provincial Officers.

Mr. V. W. Morton.
Mr. T. P. Dewar.
Mr. A. A. Graham.
Mr. H. St. J. Kenny.
Mr. A. J. Booth.
Mr. R. M. Wyatt.

Lower Subordinate Service.

28 Surveyors, etc.

The party commenced work this season in the area allotted to it in the reorganisation of the Department. The usual long journey to the field only permitted of a field season of just over 4 months. One section left Maymyo at the end of October and did not reach its field head-quarters till the 18th December, and some of the surveyors did not start work till the 26th December. The rest of the surveyors left Maymyo on the 15th November and had all commenced work by the 20th December. Field work closed between the 20th April and 3rd May, and the majority of the surveyors were back in recess quarters by the 16th May, but some did not arrive till the 2nd June. The programme was completed as usual in this party.

The triangulation owing to unavoidable circumstances was carried out by two inexperienced observers who did not work to the best advantage. A lot of time was lost in waiting for the haze to clear and consequently the cost-rate is higher than usual.

Contours were inserted with a vertical interval of 100 feet except in sheet 94 $\frac{E}{2}$ which included the wide plain round the market town of Loikaw where the 50 feet interval was employed. The country surveyed was sparsely inhabited, the hills were generally open though steep, and in most parts broken and rocky; communications were very bad, and supplies and labour presented many difficulties. The cost-rate for detail survey is high this season owing to the great distance from the railway and the wild and uninhabited nature of the country. Escorts of Military police were provided to several of the surveyors working along the Siamese frontier.

As a large part of the area under survey lay close along the Salween river, work was much interrupted by morning mists in December and January, whilst the smoke haze in March was thick and persistent. Many surveyors had to stop work for two or three days at a time when hills only a mile distant were blotted out by haze. No rain fell from the beginning of December till the middle of April and the heat was intense in the river valleys. Nearly all the trees are deciduous, and the hills were practically bare during February and March. Burning of the jungle commenced in February and the whole country then became dry and burnt up and hill climbing was more like work in Baluchistān than Burma. In the trans-Salween area of the Southern Shan States the villages numbered about 1 to 20 square miles and these were by no means evenly distributed. In Sheet 94 $\frac{E}{1}$ there was a tract over 180 miles square with but 2 villages. In Karenni villages were more numerous but the people were useless. There was great scarcity of rice throughout and it had to be sent out from the Shan centres to the surveyors. Nowhere was it so expensive as in the prosperous Karen city of Ywathit where it was over one rupee for 4 viss, a viss being equal to $3\frac{1}{3}$ pounds. Here all rice is brought by bullocks from Loikaw or by boat from the direction of Mawkmai in the Shan States.

Some difficulty was found in following the boundaries between the small Karenni States, and the Assistant Political Officer, Mr. Carey, went round and pointed them out personally, thus ensuring their being correctly surveyed.

About 200 miles of the boundary between Burma and Siam were surveyed. The surveyors were forbidden to cross the frontier into Siam, and as the boundary runs along a watershed the whole way and the hills were heavily wooded, very little ground beyond the boundary was sketched in, with the exception of that part lying in Sheet 94 $\frac{M}{1}$. The greater part of this sheet had been surveyed in 1909-10 in connection with a dispute as to the boundary, and here a considerable amount of the country beyond the boundary line has been mapped. All pillars mentioned in the Boundary Commission Report of 1893 were found except one at a spot where the boundary crosses the Mè Pai river.

No forests fell into the area under survey, but a theodolite traverse was done of the boundary of the Tamhpak reserve of the Southern Shan States division in Sheet 94 $\frac{E}{6}$ amounting to 76 linear miles, and the reserve will be surveyed on the 2 inch scale next season.

Recess duties.—All the 17 sheets surveyed were fair mapped during the recess and forwarded to the Circle Office for publication. Their numbers are 94 $\frac{E}{3,\ 9,\ 10,\ 11,\ 12,\ 13,\ 14,\ 15,\ 16}$, 94 $\frac{I}{1,\ 2,\ 5,\ 6,\ 9,\ 10,\ 13}$ and 94 $\frac{M}{1}$.

Small areas previously omitted in Sheets 93 $\frac{P}{7}$ and 94 $\frac{F}{8}$ were also surveyed and mapped.

The computations of the season's triangulation and traversing were completed and the charts and general reports of Sheets 93 O, 93 P, and 93 L were completed and despatched to head-quarters. Charts of Sheets 93 J, 94 E, and 94 I still remain to be drawn, but will be done in the Trigonometrical Office at Dehra Dūn.

No. 12 PARTY (ASSAM).

PERSONNEL.

Imperial Officers.

Major A. Mears, I.A., in charge.
Lieutenant G. F. T. Oakes, R.E.

Provincial Officers.

Mr. W. Skilling.
Mr. C. C. Byrne.
Mr. Pramada Ranjan Ray.
Mr. J. H. Williams.
Mr. Amjad Ali.
Mr. L. Williams.
Mr. P. C. Mitra.
Mr. H. H. Creed.

Upper Subordinate Service.

Mr. Nanak Chand Puri.

Lower Subordinate Service.

41 Surveyors, etc.

The operations of former seasons were continued in the Sylhet and Khāsi and Jaintiā Hills districts of Assam; the survey being carried out on the 1-inch scale, and consisting partly of original and partly of supplementary survey. The Nongkyllem reserved forest, 26 square miles in area, which fell into the area under survey and had not been previously surveyed on a large scale, was surveyed on the 2-inch scale.

Field work was commenced on the 1st November 1910 and closed at the end of April when constant rain was experienced and it was impossible to continue it any longer. The programme was not completed either of triangulation, traversing or detail survey. Of the latter, all but one standard sheet was completed and the defect was partly due to an outbreak of cholera which necessitated the removal of the surveyors temporarily from that locality, and partly to the fact that few of the surveyors had had any previous experience of survey by interpolation in open hilly country, and their progress was at first very slow. This is the first season for many years that country of this type has been met with by this party.

Triangulation.—The triangulation was executed by two Provincial officers and was based on a secondary series which had been observed the previous season by No. 15 Party, emanating from the Assam Valley series at about longitude 90° and running eastwards just north of latitude 25° 30′ to longitude 93°.

The heights of the season's triangulation were based on the Chhaygaon and Palāsbāri bench-marks of the Pārvatīpur-Gauhāti line of levelling of the Great Trigonometrical Survey, and agree very well with the original values of the Great Trigonometrical triangulation, but differ by some 5 to 7 feet from those of Mr. Bond's revisionary triangulation of 1897-98. This is probably due to the fact that Rangsonobo H. S. which was Mr. Bond's starting point, was affected by the earthquake of 1897, but was apparently assumed to be unaffected. A connection made by the Great Trigonometrical Levelling Party this season with Somullon H. S. gives a difference of only 1 foot from the trigonometrical height, whereas Mr. Bond's triangulation differs by 5·5 feet from the original height.

Triangulation being impossible over a large part of the area required to be prepared for detail survey, traversing had to be resorted to. Two traversers were employed on this for the whole field season and a third for about 4 months, and an area of 1,600 square miles was thus prepared for detail survey. The greater part of the area traversed consisted of open cultivated country which had been cadastrally surveyed in 1892-95, and only a few traverses were necessary in this part to provide heights. Adjoining the Bhutān frontier, however, where there is much dense jungle, the traverses had to be run close together, and the work was very slow. The stations were only temporarily marked by wooden posts in the jungle and wooden pegs in the open cultivated lands, three consecutive stations every two miles or so, being marked by galvanised iron cylinders embedded in the ground and a mound of earth raised over them. There were 415 cylinders embedded and 489 linear miles of traversing.

The area surveyed in detail comprised very varied country, a narrow strip of country at the foot of the Khāsi hills being flat and open, while the hills themselves were precipitous and densely wooded in places and open rolling downs in others.

The supplementary survey was mainly based on the traversing of the cadastral survey of 1892-95; but the details of the cadastral maps were found to have altered so much owing to the length of time that has elapsed since the cadastral survey was carried out, and to the fact that almost the whole country is submerged annually during the rainy season, that the work practically amounted to a new survey.

Cost-rates.—The cost-rates are all affected by the difficulty experienced in obtaining labour for jungle clearing, and for transport purposes in the hills, where carts were impracticable and the wages paid very high. In the part of the Khāsi hills which was triangulated, villages were few and far between and the communications very bad.

The cost-rate for triangulation and traversing is low this season for the reason given above, that the traversing of the cadastral survey was found sufficient and very little fresh traversing was required in that area. The cost-rate for original 1-inch detail survey is slightly higher than last season's, which considering the nature of the country and the larger outturn of this season should not have been the case; but the increase must be ascribed to the causes etailed above, to which the failure to accomplish the programme was due.

The cost-rate for 2-inch original forest survey is considerably less than last season's, but this was due to the easy nature of the small area surveyed on that scale this season. The cost-rate of the supplementary survey is somewhat lower than that of last season, due also to the easier nature of the country.

Recess work.—The mapping this season was almost completed when the party took the field again and the following sheets were submitted to the circle office for completion and publication $78 \frac{O}{3, 4, 7, 8, 10, 11, 12, 13, 14, 15, 16}$ and $83 \frac{D}{1}$. The triangulation chart of Sheet 83 D which was commenced the previous season was completed, and also the general report thereof, and both forwarded to the Trigonometrical Office. This is the last chart that will be drawn by the party.

The boundaries of the various petty States in the Khāsi and Jaintiā Hills are not defined, but at the request of the Local Government, the names of the States have been entered on the fair maps.

TABLE I.

OUT-TURNS OF DETAIL SURVEY.

Scale.	Class of survey.	Circle.	Party.	Locality.	Class of Country.	Out-turn. Total square miles.	Out-turn. Average per man per month in square miles. (b).	Average number of fixings per square mile.
1-inch .	Survey .	N	No. 1	Kashmir . .	Hilly . . .	3,514	33·0	6·4
		N	No. 2	Punjab .	Level plains . .	4,971	60·5	41·6
		N	No. 4	United Provinces	Level plains and broken ground.	4,933	25·9(a)	19·0(a)
		S	No. 5	Central Provinces and Central India.	Open cultivated plains.	874	21·4	12·7
		S	No. 6	Bombay, Central Provinces, Berār and Hyderābād.	Varied . . .	2,223	21·2	22·0
		S	No. 7	Bombay, Madras, Mysore and Coorg.	Part open, part hilly and wooded.	734	16·8	26·0
		S	No. 8	Madras . .	Part flat, enclosed, part hilly forest.	910	14·2	24·8(c)
		N	No. 9	Punjab . .	Flat, open, part desert.	2,176	23·8	11·4(a)
		E	No. 10	Upper Burma .	Densely wooded and generally hilly.	2,615	25·7	13·0
		E	No. 11	Southern Shan States and Karenni.	Steep rocky hills, lightly wooded.	3,229	31·2	6
		E	No. 12	Assam . .	Wooded hills . .	2,720	21·6(a)	11(c)
1-inch .	Revision .	N	No. 3	Punjab and United Provinces.	Flat open country .	5,955	30·1(a)	13·0(a)
		S	No. 5	Central Provinces and Central India.	Cultivated plains and wooded hills.	2,919	128·3	2·5
		S	No. 6	Bombay, Berār and Hyderābād.	Varied . . .	770	24·7	14·0
		S	No. 7	Madras, Mysore and Coorg.	Bold forest-clad hills	1,783	38·2	7·0
1-inch .	Re-survey	N	No. 9	Punjab . .	...	1,304	23·8	11·4(a)
1-inch .	Supplementary Survey.	N	No. 3	Punjab and United Provinces.	Flat open country .	262	30·1(a)	13·0(a)
		N	No. 4	United Provinces	...	1,115	25·9(a)	19·0(a)
		N	No. 9	Punjab .	Flat, open, part desert.	2,207	23·8	11·4(a)
		E	No. 12	Assam . .	Open plains . .	445	21·6(a)	9(c)
1½-inch .	Survey .	S	No. 5	Central Provinces and Central India.	Cultivated plains and wooded hills.	1,373	16·1	25·7
		S	No. 7	Madras, Mysore and Coorg.	Flat open with tidal creeks.	556	13·6	29·0
		S	No. 8	Madras . .	Flat enclosed .	81	5·8	56·7(c)
2-inch .	Survey .	N	No. 2	Punjab . .	Hilly with deep ravines.	1,026	17·2	34·4
		S	No. 6	Bombay, Berār and Hyderābād.	Dense scrub-jungle .	97	5·7	72
		S	No. 8	Madras . .	Part flat enclosed, part hilly dense forest.	296	7·7	35·9(c)
		E	No. 10	Upper Burma .	Densely wooded .	183	9·6	82
		E	No. 12	Assam . .	Dense hilly forest .	26	5·5	79·8(c)
2-inch .	Revision .	N	No. 3	Punjab . .	Delhi city and ridge	65	21·1	17·7
		S	No. 7	Madras, Mysore and Coorg.	Hilly forest . .	555	46·1	7·0

(a) Includes all kinds of 1-inch survey.
(b) The average outturn per month has been taken assuming 24 working days per month. This has been done so that the different parties may be compared together.
(c) Including P. T. traverse fixings.

TABLE II.

DETAILS OF TRIANGULATION AND TRAVERSING.

Circle.	Party.	Locality.	TRIANGULATION.												TRAVERSING.				
			Instrument used; diameter in inches.	Area in square miles.	Square miles to each point fixed.	Square miles to each height.	MINOR.			TERTIARY.			INTERSECTED POINTS.		Area in square miles.	Linear miles of chaining.	Number of stations at which theodolite was set up.	Angular error per station in seconds.	Linear error per 1000.
							Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Stations fixed.	Triangular error in seconds.	Linear error per mile in feet.	Number of points fixed.	Linear error per mile in feet.					
N	No. 1	Kashmir . . .	6	3,079	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N	No. 2	Punjab . . .	5 & 6	...	...	...	...	...	...	...	...	...	...	...	...	71	217	...	4
N	No. 3	Punjab and United Provinces.	6	325	5·5	5·5	...	...	...	12	17·7″	0·4	45	3·9	...	...	...	...	...
N	No. 4	United Provinces .	...	...	...	...	...	...	...	...	...	...	...	...	6,236	1,905	5,662	1 in 9	0·35
S	No. 5	Central Provinces .	6 & 7	2,512	2·4	2·5	...	...	...	108	10″	0·2	1,044	0·6	...	...	...	...	...
S	No. 6	Bombay and Berār .	6	3,360	(a)	(a)	(a)	8·4	0·2	(a)	11·7	0·2	(a)	...	...	804	5,716	2	0·8
S	No. 7	Madras, Mysore .	6	1,769	6·6	6·5	...	...	0·2	11	15·0	0·3	258	0·8	...	...	...	...	...
S	No. 8	Madras . . .	6	279	3·8	3·4	10	8·0	0·1	...	...	...	71	0·5	...	85	1,593	3	1·0
N	No. 9	Punjab . . .	6	3,575	...	...	...	...	...	...	...	...	376	...	...	67	...	...	...
E	No. 10	Upper Burma . .	6	1,775	11·5	12·5	19	10·0	0·2	...	...	...	129	0·5	1,850	369	5,717	1·05	0·8
E	No. 11	Southern Shan States	6	1,850	5·0	6·0	26	9·2	0·2	22	7·6	0·2	303	0·4	...	76(b)	...	...	...
E	No. 12	Assam . . .	6	2,440	5·9	6·2	...	...	...	58	8·6	0·2	351	0·8	1,600	489	1,914	10·6	2·0

(a) Computations incomplete. (b) Boundary traverse.

TABLE III.

COST-RATES OF SURVEY.

Circle.	Party.	Locality.	Class of country.	Cost-rates, Rupees. Detail Survey per square mile. 1-inch survey.	1-inch revision.	1-inch resurvey.	1-inch supplementary survey.	1½-inch survey.	2-inch survey.	2-inch re-survey.	Triangulation per square mile. Minor and tertiary.	Traversing per linear mile. Topographical.	Forest boundary.	Fair mapping per square mile.	Total survey outturns on all scales, square miles.	Total cost of party. Rs.	Inclusive cost-rate per square mile.	Remarks.
N	No. 1	Kashmir	Hilly	15·7	...	...	...	...	...	...	9·8	...	...	...	3,514	1,10,162(a)	31·3	(a) Excluding Rs. 3,840 for Field Service press experiments.
N	No. 2	Punjab	Level plains	9·4	...	...	...	...	28·4	...	...	39·2	...	7·6(b) 2·0(c)	5,997	1,23,724(d)	20·6	(b) Cost-rate for 2" work.
N	No. 3	Punjab and United Provinces.	Flat and open	...	...	11·3	10·0	...	...	35·7	2·6	...	...	5·3	6,282	1,06,721	17·0	(c) Cost-rate for 1" work.
N	No. 4	United Provinces	Level plains and broken ground.	9·6(f)	...	...	...	...	...	...	...	15·5	...	5·1	6,048	1,06,814(e)	17·7	(d) Excluding Rs. 3,909 for exploration and a Special Military Survey of Dera Ismail Khān.
S	No. 5	Central Provinces and Central India.	Cultivated plains and wooded hills.	19·3	2·1	...	...	21·34	...	...	11·2	...	...	7·0	5,166	1,06,642	20·6	
S	No. 6	Bombay, Berār and Hyderābād.	Plains and scrub jungle	13·2	10·0	...	...	...	37·8	...	7·5	...	19·1	9·6	3,090	1,13,507	36·7	(e) Excluding Rs. 13,848 on local surveys.
S	No. 7	Madras. Mysore and Coorg.	Various	24·4	...	15·1	...	28·5	...	7·7	2·7	...	...	7·2	3,628	93,641	25·8	
S	No. 8	Madras	Flat enclosed and dense forest.	43·5	...	...	...	46·3	93·7	...	45·1	38·6	...	11·4	1,287	1,16,486	90·5	(f) Cost-rate for all kinds of 1" survey.
N	No. 9	Punjab	Flat, open and partly desert	10·9(f)	...	...	...	...	...	...	5·2	15·2	...	2·8	5,687	96,277(g)	16·9	
E	No. 10	Upper Burma	Partly flat, partly hills	25·1	...	...	...	...	57·9	...	8·8	58·7	...	8·8	2,798	1,40,177(h)	50·1	(g) Excluding Rs. 16,901 on Baluchistān work.
E	No. 11	Southern Shan States.	Steep, rocky hills	31·8	...	...	...	...	...	...	13·2	...	55·1	4·3	3,229	1,45,153	44·7	
E	No. 12	Assam	Plains and partly forest-clad hills.	30·0	...	...	13·5	...	56·6	...	10·9	21·7	...	7·6	3,191	1,50,477	47·2	(h) Excluding Rs. 41,395 on reconnaissance and local surveys.

PART II.—GEODETIC SURVEY.

ASTRONOMICAL LATITUDES.

No. 13 PARTY.

(*Vide* Index map 10).

BY LIEUTENANT-COLONEL G. P. LENOX-CONYNGHAM, R.E.

PERSONNEL.
Imperial Officer.
Major H. L. Crosthwait, R.E., in charge.

The programme of observations for the season 1910-11 consisted of two separate parts. The first part included the observation of six astronomical latitudes in Sind and Baluchistān, and the second part consisted of the addition of four latitudes in the Siwāliks ; it had been intended to include two more stations in the latter region, but the abnormally wet and cloudy weather of March 1911, and the fact that the officer in charge had to go to Simla at the beginning of April to take over the Simla Drawing Office prevented the completion of the original plan.

2. Major H. L. Crosthwait, R.E., held charge of the Party throughout the year and made all the astronomical observations. During the recess season, though Major Crosthwait continued to be in nominal charge, the work of the party was supervised by Lieutenant-Colonel G. P. Lenox-Conyngham, R.E.

3. The instrument used was the zenith telescope by Messrs. Troughton and Simms, which has been in regular use as the chief latitude instrument of the department since 1880.

4. *The constants of the instrument and results of the operations.*—The levels mounted on the zenith telescope were Nos. 9 and 10 by Holmes.

Determinations of their scale values were made on the bubble tester both before and after the field observations.

The results were not very satisfactory, as there is a good deal of difference between the values obtained before the field work and those obtained after it.

As there was no means of saying which of the two values was the more trustworthy, the mean has been used for the reduction of the observations.

The values obtained were—

	Level No. 9.	Level No. 10.
Mean value of 1 division before field work	0″·935	0″·829
,, ,, ,, ,, after ,, ,, ...	0″·916	0″·805
Mean used in reduction .	0″·925	0″·817

There is clearly an uncertainty of at least 2 per cent. in the level corrections deduced from these mean values ; but as the mean magnitude of the level correction is less than 1 inch, and as there is no tendency for it to be of persistent sign, the error in the final latitudes due to this uncertainty is probably extremely small.

5. The micrometer value was determined by means of measurement of the differences between the declinations of well known couples of stars. Sometimes these observations were fitted in among the latitude observations, and sometimes a special night, or more than one, was devoted to the business.

The results obtained were as follows :—

Value of 1 revolution of micrometer at	Quetta . . .	69″·177
" " "	Mach . . .	69″·180
" " "	Dasti . . .	69″·176
" " "	Dumb . . .	69″·177
" " "	Sultān ka Got . .	69″·192
	GENERAL MEAN .	69″·181

No observations were made at the other stations. These results are very satisfactory, and give great confidence in the truth of the value obtained: nevertheless in order to test it still further, abstracts were prepared of the observed latitudes according as positive or negative micrometer corrections entered into their formation, in order to see whether there was any sign of a systematic difference.

The results are shown in the following table :—

STATION.	Mean colatitude from observations giving positive micrometer corrections $=C_1$.	Value of mean positive micrometer correction $=M_1$.	Mean colatitude from observations giving negative micrometer corrections $=C_2$.	Value of mean negative micrometer correction $=M_2$.	Apparent error of value of 1 revolution of micrometer $=\frac{C_1-C_2}{100\,(M_1+M_2)}$
	″		″		″
Quetta . . .	4·00	1908	3·66	2078	+0·0085
Khojak . . .	39·40	2226	39·47	2534	−0·0015
Mach	39·50	2211	39·28	1770	+0·0055
Dasti	32·50	2506	32·32	2225	+0·0027
Dumb . . .	41·80	2534	41·61	1939	+0·0042
Sultān ka Got . .	51·94	2206	51·94	2549	±0
Shorpur . . .	44·67	1990	44·34	2174	+0·0079
Bullawalla . . .	37·83	2893	37·41	1830	+0·0089
Lachkua . . .	54·65	2898	54·48	1711	+0·0037
Hatni . . .	28·28	2237	27·49	2748	+0·0158

The mean of the deduced apparent errors at the six Baluchistān and Sind stations is +0″·003.

This quantity hardly exceeds the probable error of the adopted mean value and our confidence in the latter is therefore increased.

The mean apparent error deduced from the observations at the Siwālik stations is +0″·009: this quantity, though larger than that derived from the Sind stations, is still not excessive; and any ill effects will be easily cancelled by producing a balance between the positive and negative micrometer corrections before taking a final mean.

6. The results of the season's operations are as follows :—

STATION.	Longitude.		Height above M. S. L.	Geodetic Latitude = G.			Seconds of Astronomical Latitude and probable error = A.		A—G.
			Six Baluchistān Stations.						
	°	′	feet	°	′	″	″	″	″
(i) Khojak	66	37	7851	30	51	24·85	20·21	±0·061	— 4·64
(ii) Quetta	67	3	5500		11	57·37	55·91	±0·098	— 1·46
(iii) Mach	67	21	3522	29	52	31·51	20·46	±0·058	—11·05
(iv) Dasti	67	56	316		0	29·93	27·61	±0·058	— 2·32
(v) Dumb	68	17	183	28	15	21·09	18·30	±0·048	— 2·79
(vi) Sultān ka Got	69	39	213		4	9·41	8·05	±0·045	— 1·36
			Four Siwālik Stations.						
(vii) Lachkua	78	2	2674	30	4	34·24	5·34	±0·050	—28·90
(viii) Hatni	77	59	3096		13	1·52	31·93	±0·096	—29·59
(ix) Bullawalla	77	59	2432		6	51·29	22·32	±0·058	—28·97
(x) Shorpur	77	58	2916		13	44·43	15·30	±0·073	—29·13

A negative value of (A—G) denotes a northerly attraction of the plumb line.

The topography of the stations—

(*i*) *Khojak* is on one of the peaks of the Khwāja Amrān range which runs from N.N.E. to S.S.W. in an almost straight line. The distribution of the mountain masses within a radius of 50 miles is such as to lead one to expect no marked deflection of the plumb line.

(*ii*) *Quetta*—Here again there is an apparent balance of masses to the north and south, and no cause for a deflection of the plumb line can be found.

(*iii*) *Mach* is situated on the Bolān valley about half way down from the point where the descent from the Dasht begins. There is a notable excess of mountain masses to the north of this station. To the south-east, the hills fade away into the plains, the foot being about 20 miles distant to the south, and the hills are much less lofty than to the north. A northerly attraction is therefore to be expected at this station.

(*iv*) *Dasti* is in the plains ; the nearest hills are about 25 miles distant in a north-west direction. To the north the foot of the hills is about 40 miles distant. If we consider a belt lying between circles of 40 and 80 miles radius respectively, we may estimate that the portion of it from west to north-east (clockwise) is occupied by hills, the average height of which is 5,000 feet greater than that of the land occupying the remaining

five-eighths. The attraction in the plane of the meridian will then be—

$$0''\cdot000742\times5000\times1\cdot766=6''\cdot6 \ *$$

This may be taken to be a rough approximation to the effect of the visible masses within a radius of 80 miles of the station. If the investigation were extended, a larger attraction to the north would undoubtedly be indicated, for the country to the north is all elevated while that to the south is low-lying.

(*v*) *Dumb* is in the plains a few miles to the west of Jacobābād ; the nearest hills lie about 30 miles to the north-east and 50 miles to the west, indicating that a northerly attraction might be expected.

(*vi*) *Sultān ka Got* is similar to Dumb, but the hills are now more remote.

(*vii*) Of the four Siwālik stations, Lachkua, Hatni, and Bullawalla are on the southern slopes of the Siwālik range (that is on the side remote from Dehra Dūn and the Himālaya), while Shorpur is on the main ridge of the range close to the Mohan Pass by which the Sahāranpur road enters the Dūn.

7. *The deflections of the plumb line.*—The deflections found at the stations in Baluchistān and Sind are remarkable in the first place for their smallness.† The hills of Baluchistān and Afghanistan, though they do not rival the Himālaya in height, are nevertheless a mighty mass, and in one respect have an advantage over the Eastern ranges as a source of attraction on the plumb line. The Himālaya are annually subjected to an extremely heavy rainfall, and in consequence great and numerous rivers have cut deep valleys for themselves, and left but a remnant of what the mass would have been but for the action of denudation and erosion. It is only beyond the great wall of the main Himālayan range, which finally exhausts the monsoon current of its moisture, that an elevated plateau of any considerable extent is to be found ; the latitude stations of the submontane tracts and of the outer range are therefore within close touch of ridges only, not of high plateaux.

In the arid regions of Sind and Baluchistān, however, the action of water has been much less, and within a distance corresponding only to that, for instance, of Simla from the plains, we come to wide expanses of elevated land, with peaks and ranges rising above them, but without deep valleys. In a computation of the effects of visible masses by the zone system it would be found that the mean height of the nearer, and therefore more important, zones

* *Vide* Professional paper No. 5, page 50.

† If, as there is reason to believe (*vide* Phil. Trans. Series A, Vol. 205, page 313) the plumb line at Kalianpur, the station of origin of the triangulation, is subject to a southerly deflection of about 6″, then all the geodetic latitudes must be diminished by this quantity, and the values of (A—G) given on page (26) will become

	″
Khojak	+ 1·36
Quetta	+ 4·54
Mach	— 5·05
Dasti	+ 3·68
Dumb	+ 3·21
Sultān ka Got	+ 4·64

that is to say, southerly deflections will be indicated at all the stations except Mach. This emphasises the discord between the observed results and those which a calculation of the effects of the visible masses would lead to.

surrounding the Baluchistān stations, would not fall far short of that found at similar distances in the case of Himālayan stations.

8. The uniformity of the deflections at the three southernmost stations, Sultān ka Got, Dumb and Dasti, seems to indicate that the mountains to the north exert no effective influence. The form of these ranges however is not so simple as that of the Himālaya ; the lobe of mountainous country which has the appearance of having been squeezed through an aperture lying between Dera Ghāzi Khān and Sibi, and the tongue of flat land which extends from the plains of Sind up to the latter place, are remarkable features, and may point to a more complicated substructure than the ditch and hidden chain, parallel to the mountain range, which the deflections of the plumb line and the variations of gravity have revealed in the region that lies under the shadow of the Himālaya.

9. It has been suggested with much plausibility that the whole of the mountains extending from Burma to Sistān are due to a surface flow or creep from the north-east which has encountered an obstacle in the continent of India. This obstacle has arrested the flow all along the line of the Himālayas from Sadiyā to Peshāwar, but there came to an end, so that the flow proceeded all along the Indus Valley forming the Sulaimān Mountains, the lobe alluded to above, and the ranges of Sistān and Makrān. It seems clear that a projection of the obstacle runs up to Sibi and that the mountain tide has flowed round it on two sides. What is the nature of the obstacle? If at the foot of the ranges there was a mass of archæan rocks, it might be readily conceded that it would offer the opposition postulated, but instead of a mass of ancient rock, there are wide plains of alluvial deposits the depth of which is known to be very great, perhaps as great as the height of the highest peaks that stand above them.

If the theory of the flow from north-east is correct, it seems clear that resistance must have been encountered at a great depth, and that the action may resemble that which causes breakers to rise, curl over and fall on the sea-shore. We do not, it is true, see the mountains taking the precise form of curling waves, but it must be recollected that the movements in the case of mountains are extremely slow, and that the uplifted mass is at all times suffering denudation by the action of rain, frost and wind, so that the softer portions, at any rate, are cut away almost as fast as they are raised.

10. The tongue of land that runs up from Shikārpur to Sibi and the line of the Indus are regions which deserve careful study. At Jacobābād, the pendulums shewed an excess of density, at Sibi a defect. More pendulum stations are required, or it is possible that the investigation could be more satisfactorily made by means of Baron Eötvös's gravity balance, if we were equipped with one. In comparison with the sub-Himālayan tracts this region is ill provided with stations of triangulation at which latitude observations might be made with advantage, but if a good portable pendulum room could be devised there is no reason why a number of gravity determinations should not be made. Up the Indus Valley, the north and south lie of the mountain ranges deprives measurements of the deflection of the plumb-line in the meridian of their value, but here again the pendulum would yield useful information.

11. The results of the observations in the Siwāliks are remarkable for their uniformity. It does not seem to make any difference whether the station is on the southern slope, on the crest, or on the northern slope of this range, the deflection appears to be always about the same. The mass of the Siwāliks

is, however, small, and analysis may show that the observed deflections are satisfactorily accounted for by known causes; the greater distance of the stations on the southern Siwālik slope from the Himālaya, and the greater proximity to the hidden chain, being sufficient cause for the slightly smaller northerly attractions of the plumb-line found there. It is doubtful whether we possess sufficiently detailed maps of the Siwāliks to permit of an analysis of such refinement as to explain differences of fractions of a second, but it will be possible at any rate to indicate limits within which the effects of the visible masses must lie, and to say, therefore, whether any special and invisible cause must be postulated to account for the observed phenomena.

PENDULUM OPERATIONS.

No. 14 PARTY.

(*Vide* Index map 10).

BY MAJOR E. A. TANDY, R.E.

PERSONNEL.

Imperial Officers.

Captain H. M. Cowie, R.E., in charge up to 2nd May 1911.
Major E. A. Tandy, R.E., in charge from 3rd May 1911.
Captain H. J. Couchman, R.E., attached from 26th September 1911.

Provincial Officer.

Mr. Hanuman Prasad.

During the season 1910-11 pendulum observations were made in Burma, where gravity was determined at eleven stations fairly evenly distributed between Mogok in the north and Bassein and Rangoon in the south.

The whole of the field work was done by Captain H. M. Cowie, R.E., assisted by Mr. Hanuman Prasad who took the time observations, and also did the pendulum computations during recess.

The following table gives the position and height of the stations visited :—

TABLE I.

Station.	Latitude.	Longitude.	Height above mean sea level.
	° ′ ″	° ′ ″	feet.
1. Rangoon	16 47 55	96 9 8	164
2. Prome	18 49 40	95 13 40	101
3. Henzada	17 39 17	95 27 18	46
4. Bassein	16 47 11	94 44 6	23
5. Toungoo	18 55 50	96 27 3	159
6. Pyinmanā	19 44 25	96 11 56	409
7. Meiktila	20 51 26	95 51 58	799
8. Mandalay	21 59 44	96 6 28	244
9. Maymyo	22 1 13	96 28 24	3,495
10. Mogok	22 54 51	96 29 51	3,685
11. Myingyan	21 28 56	95 23 50	248

Pucca buildings were provided at all stations, and conditions for control of temperature, etc., were quite satisfactory, with the following exceptions :—

At Bassein and Toungoo the floors were bad, and the rooms rather unsuitable and in bad repair, so that temperature control was very difficult ; at Prome and Meiktila the temperature control also presented some difficulties on account of insufficient protection from the sun.

The average temperatures and their hourly variations are given in the following table :—

TABLE II.

STATIONS.	NIGHT.		DAY.		MEAN.	
	Average temperature.	Hourly change.	Average temperature.	Hourly change.	Average temperature.	Hourly change.
	° C	° C	° C	° C	° C	° C
Dehra Dūn, October 1910	24·00	+0·07	23·45	+0·14	23·73	+0·11
Rangoon	25·96	+0·03	25·35	+0·09	25·65	+0·06
Prome	26·35	+0·01	23·06	+0·20	24·71	+0·10
Henzada	26·23	+0·01	24·33	+0·03	25·28	+0·02
Bassein	24·74	—0·10	22·45	+0·20	23·59	+0·05
Toungoo	23·11	—0·12	20·34	+0·60	21·73	+0·24
Pyinmanā	24·56	+0·04	23·05	+0·16	23·80	+0·10
Meiktila	24·92	—0·13	21·39	+0·41	23·16	+0·14
Mandalay	22·61	+0·08	22·51	+0·06	22·56	+0·07
Maymyo	13·52	+0·05	13·03	+0·27	13·28	+0·16
Mogok	16·85	—0·17	15·95	+0·47	16·40	+0·15
Myingyan	30·44	+0·12	30·65	+0·08	30·54	+0·10
Dehra Dūn, April 1911	26·37	+0·08	26·00	+0·15	26·19	+0·12

Observations for *flexure* were made at the commencement and close of work at each station. The following table gives the observed flexure corrections and the mean adopted for each station. The amounts range from $33^{s}\cdot5\times10^{-7}$ to $52^{s}\cdot3\times10^{-7}$.

TABLE III.

Station.	Date.	Observed flexure correction.	Adopted flexure correction.
		Sec.	Sec.
Dehra Dūn . . .	17th October 1910 . .	$37\cdot7\times10^{-7}$	
	23rd „ „ . .	37·4	$37\cdot6\times10^{-7}$
Rangoon . . .	18th November 1910 . .	53·1	
	23rd „ „ . .	51·4	52·3
Prome . . .	28th „ „ . .	41·5	
	3rd December „ . .	40·5	41·0
Henzada . . .	10th „ „ . .	38·3	
	14th „ „ . .	37·6	37·9
Bassein . . .	17th „ „ . .	50·5	
	21st „ „ . .	49·4	50·0
Toungoo . . .	2nd January 1911 . .	42·7	
	7th „ „ . .	42·9	42·8
Pyinmanā . .	14th „ „ . .	34·7	
	18th „ „ . .	33·5	34·1
Meiktila . . .	23rd „ „ . .	34·9	
	27th „ „ . .	35·1	35·0
Mandalay . .	2nd February 1911 . .	33·3	
	6th „ „ . .	35·6	34·5
Maymyo . . .	11th „ „ . .	34·9	
	14th „ „ . .	33·9	34·4
Mogok . . .	1st March „ . .	42·2	
	5th „ „ . .	41·7	42·0
Myingyan . .	19th „ „ . .	33·6	
	23rd „ „ . .	33·5	33·5
Dehra Dūn . .	16th April „ . .	35·9	
	22nd „ „ . .	36·3	36·1

2. Table IV shows the *times of vibration* of the four pendulums at Dehra Dūn in October and April.

TABLE IV.

Date.		137	138	139	140	Mean.
	1910.					
Oct.	17—18	0^{s}·5072582	0^{s}·5074972	0^{s}·5071591	0^{s}·5070872	0^{s}·5072504
	18—19	2562	4977	1572	0865	2494
	19—20	2568	4959	1586	0860	2493
	21—22	2579	4976	1599	0874	2507
	Means .	0^{s}·5072573	0^{s}·5074971	0^{s}·5071587	0^{s}·5070868	0^{s}·5072500
	1911.					
Apl.	17—18	0^{s}·5072567	0^{s}·5074994	0^{s}·5071608	0^{s}·5070872	0^{s}·5072510
	18—19	2557	4976	1596	0867	2499
	19—20	2574	5007	1620	0884	2521
	20—21	2545	4988	1601	0867	2500
	Means .	0^{s}·5072561	0^{s}·5074991	0^{s}·5071606	0^{s}·5070873	0^{s}·5072508
General means adopted for season.		0^{s}·5072567	0^{s}·5074981	0^{s}·5071597	0^{s}·5070870	0^{s}·5072504
Differences, April—Oct.		—12	+20	+19	+5	+8

In the Narrative Report for 1908-09 a diagram was given showing the variations in the time of vibration of each pendulum, as observed at Dehra Dūn at the commencement and close of each field season, from the time of the first observations in January 1904.

These curves have been carried on to date, and it is interesting to note that, whereas the mean pendulum showed a change which would correspond with a decrease in gravity at Dehra Dūn of nearly ·02 dynes between January 1904 and November 1909, since the latter date there has been a steady rise amounting to ·01 dyne up to April 1911. While individual pendulums have their own fluctuations from the mean of the four, it is rather remarkable that in every one of them the curve is at its highest in January 1904 and at its lowest in November 1909, with a distinct rise since; even the least conformable pendulum, No. 140, falls ·01 dynes between January 1904 and November 1909 and has risen ·006 dynes since the latter date.

Gravity units have been used in the above discussion, not in order to suggest that changes in the force of gravity at Dehra Dūn are the true cause of those fluctuations, but to show the kind of significance they bear in relation to our general results.

In the present state of knowledge on the subject these variations are treated as being due to changes in length of the pendulums—(a change of length of $\frac{1}{60,000}$

DIAGRAM SHOWING CHANGES

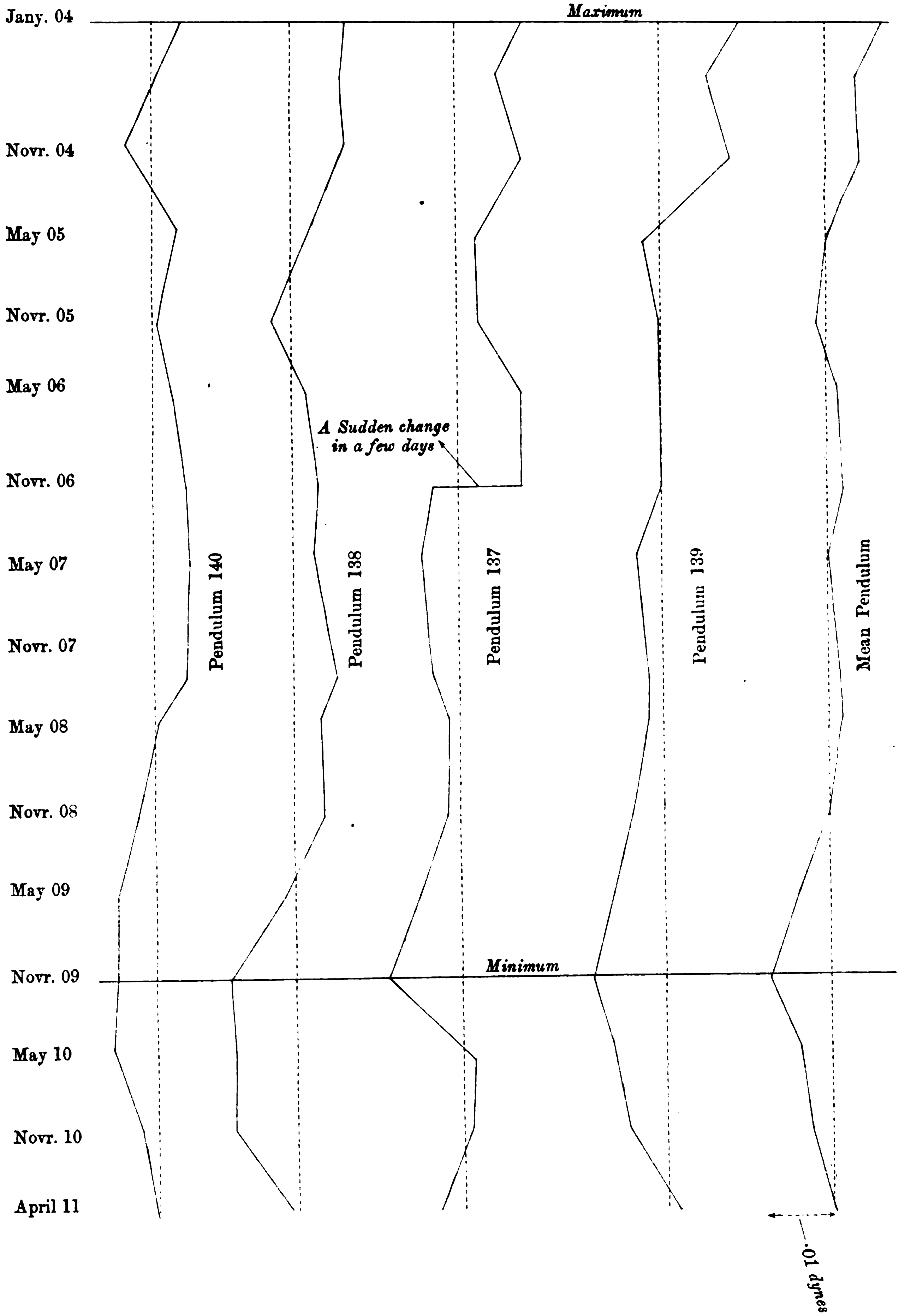
IN

RATE OF VIBRATION OF PENDULUMS

AT

DEHRA DŪN

From Jany. 1904 to April 1911



of an inch in the mean pendulum would cause a difference of ·01 dynes in the result); and the gravity observed at all other stations is deduced on the assumption that gravity at Dehra Dūn is invariable, and that the fluctuations found there are due to instrumental changes which must be allowed for each season.

When however all the pendulums begin to show an accordance somewhat greater than one would expect from such obscure individual causes of fluctuation, it becomes desirable to consider the possibility of their all being similarly affected by some other exterior cause.

The above noted accordance seems sufficiently remarkable to deserve watching. The question has been referred to Captain H. M. Cowie, R.E., who has done all the observations of the last three years; but he was only able to say that he knew of no change in procedure, or in dealing with temperature or other conditions, which could account for the curve reaching a minimum in November 1909 or indeed for any change whatever during the whole period of his work; and that in such foreign records as he had seen, no further grounds had been suggested for such changes. A diagram showing the curves of the mean pendulum and the separate pendulums up to date is attached.

3. In Table V are shown the values of "g" deduced for all stations, taking that at Dehra Dūn as 979·063 dynes, together with the observed times of vibration of the mean pendulum from which these values are deduced.

TABLE V.

Station.	Time of Vibration.	Difference from Dehra Dūn.	Observed value of g.
	Sec.	Sec.	Dynes.
Dehra Dūn	0·5072504	...	979·063
Rangoon	0·5074048	0·0001544	978·467
Prome	0·5073850	0·0001346	978·543
Henzada	0·5074013	0·0001509	978·481
Bassein	0·5074027	0·0001523	978·475
Toungoo	0·5073812	0·0001308	978·558
Pyinmanā	0·5073761	0·0001257	978·578
Meiktila	0 5073660	0·0001156	978·617
Mandalay	0·5073407	0·0000903	978·714
Maymyo	0·5073988	0·0001484	978·490
Mogok	0·5073862	0·0001358	978·539
Myingyan	0·5073471	0·0000967	978·690

These results are summarised in Table VI, and compared with the theoretical force of gravity at the various stations in the usual manner; the method being as follows:—

The observed value "g" is corrected first for height to reduce it to sea level; then for "mass," which consists of subtracting from it the effect of the layer of earth between the station and sea-level, assuming that layer to consist

of an indefinite table-land of normal density equal in height to the station; finally this correction for mass is modified by a correction for "terrain" which allows for actual irregularities of the ground within 35 miles of the station, which of course is usually not a level table-land.

We thus get a value g_0'' which shows what we may suppose the observed value would have been if taken in an open plain at sea-level; this is then compared with γ_0, which is the theoretical value of gravity at sea-level as computed for the latitude of the station.

The differences $g_0''-\gamma_0$ shown in the last column, give the differences between theory and observation which we have to consider.

TABLE VI.

Station.	Latitude.			Longitude.			Height above M. S. L.	Observed g	Correction for Height.	Correction for Mass.	Correction for Terrain.	g_0 = g corrected for Height only.	g_0'' = g corrected for Height, Mass and Terrain.	γ_0	$g_0 - \gamma_0$	$g_0'' - \gamma_0$
	°	′	″	°	′	″	Feet.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.	Dynes.
Rangoon	16	47	55	96	9	8	164	978·467	+0·015	—0·006	0	978·482	978·476	978·434	+0·048	+0·042
Prome	18	49	40	95	13	40	101	978·543	+0·009	—0·004	0	978·552	978·548	978·541	+0·011	+0·007
Henzada	17	39	17	95	27	18	46	978·481	+0·004	—0·002	0	978·485	978·483	978·478	+0·007	+0·005
Bassein	16	47	11	94	44	6	23	978·475	+0·002	—0·001	0	978·477	978·476	978·433	+0·044	+0·043
Toungoo	18	55	50	96	27	3	159	978·558	+0·015	—0·006	0	978·573	978·567	978·547	+0·026	+0·020
Pyinmanā	19	44	25	96	11	56	409	978·578	+0·038	—0·014	+0·001	978·616	978·603	978·593	+0·023	+0·010
Meiktila	20	51	26	95	51	58	799	978·617	+0·074	—0·028	0	978·691	978·663	978·658	+0·033	+0·005
Mandalay	21	59	44	96	6	28	244	978·714	+0·023	—0·009	+0·001	978·737	978·729	978·728	+0·009	+0·001
Maymyo	22	1	13	96	28	24	3,495	978·490	+0·326	—0·122	0	978·816	978·694	978·730	+0·086	—0·036
Mogok	22	54	51	96	29	51	3,685	978·539	+0·343	—0·129	+0·003	978·882	978·756	978·787	+0·095	—0·031
Myingyan	21	28	56	95	23	50	248	978·690	+0·023	—0·009	0	978·713	978·704	978·696	+0·017	+0·008

The practice of previous seasons, which accords with that of other countries, has been followed in this matter; but, now that we are beginning to compare our results with various theories on the subject, it would perhaps make things clearer always to leave our observed result, g, alone, and to apply our various theoretical corrections to our theoretical γ_0, distinguishing the gammas resulting from different theories by suitable suffixes, and then comparing them with the observed g.

In any broad comparison of different hypotheses this would appear to be the most straightforward plan, but of course the figures resulting from the comparisons will be the same in either case, and the objections to a break in the continuity of procedure have to be considered.

Under the present system it is hard to say what g_0'' really is, as it consists of an observed quantity modified by theoretical corrections.

4. The time observations, by Mr. Hanuman Prasad, were made with the bent transit instrument by Messrs. Troughton and Simms; the probable error of the clock rate determined from observations on two successive nights was $\pm 0^s{\cdot}012$, the mean of the probable errors by single stars observed on two successive nights being $\pm 0^s{\cdot}048$.

5. The chief theoretical enquiry before the party lay in a consideration of how our pendulum results would fit in with the isostatic theories put forward by Mr. Hayford after a comprehensive analysis of the results of the U. S. Coast and Geodetic Survey.

A preliminary study made it clear that the effect on gravity stations in India must be computed for the whole surface of the earth, as indicated by Mr. Hayford, before the results of his hypothesis could be adequately dealt with.

This work was therefore done, using the zones, compartments and method devised by Mr. Hayford for his own work.

The principle of interpolation was very freely used, and as a result three maps of India have been prepared, each showing by contours the resultant effects of certain zones on any required point.

Small scale orographical maps in the Harmsworth Atlas were used for the outer zones 1-6, *i.e.*, from the Antipodes to 27° from the station. For the remaining zones Captain Cowie's Bathy-orographical Charts of Asia and the Indian Ocean were used up to zone 11 inclusive, bringing the work up to a distance of 400 miles from the station.

Independent estimations of the masses made by Lieutenant-Colonel Lenox-Conyngham and Captain Couchman shewed that the original estimation for each point in each map was probably correct within ·0001 dynes; and sufficient points were employed in each case to keep the errors arising from interpolation within about ·0003 dynes. It is therefore estimated that the total resultant effect of these 11 zones as estimated from the three maps will generally be correct within ·001 dynes, and even in extreme cases the error could hardly approach ·002 dynes. The accuracy of results is therefore quite up to requirements; and, considering our ignorance of the mean heights to our north and the mean depth to our south, the methods employed are distinctly more trustworthy than the data on which they are based.

It is not proposed to carry this general work for all India beyond zone 11, as the remaining zones within 400 miles can be more conveniently dealt with individually for any required station, using larger scale maps.

It will now be a comparatively slight labour to get out complete Hayford corrections for any required station.

Captain Cowie computed out "Hayford" corrections for the ground within 100 miles of each of 42 pendulum stations last recess, and made some examination of the results on the assumption that, as all the stations lay within latitudes of 20° and 30°, the effect of the outer zones would everywhere be minus in sign and would not vary very greatly in amount. The first assumption is correct, but a very rough attempt, in the case of 4 selected stations, to fill up the gap between the first 11 zones, computed this season, and 100 miles computed by Captain Cowie, seems to indicate that these outer corrections will amount to from —·010 to —·050 dynes.

Until these quantities are exactly worked out any discussion would be premature; but it seems probable that the general result for most parts of India, taking observed gravity minus gravity computed on Hayford's hypothesis, may be something like +·050; though in troughs of defective gravity such as at the foot of the Himālayas, the two quantities may agree pretty well.

This statement does not include the southern parts of the Peninsula, which have not yet been considered.

In connection with this rough estimate of +·050, it is interesting to note that this is exactly the mean residual obtained by Mr. Hayford in applying his hypothesis to 16 stations scattered over various parts of the earth, as given in his preliminary pamphlet on this subject.

PART III.—TRIANGULATION.

No. 15 PARTY.

(*Vide* Index maps 9 and 10).

BY MAJOR H. H. TURNER, R.E.

The work of this party has for some years been on the increase. In 1907 the party consisted of personnel for employment on one principal series. In the season under review, three detachments have been employed on principal, three on secondary triangulation and three more on special work, consisting of the revision of heights on the great arc series, the selection of sites for base lines, and minor triangulation work in Kashmīr to determine definitely the position and height of the peak Teram Kangri. The minor triangulation for topographical purposes in Kashmīr was also included in this year's party programme, but the detachment carrying out this work was transferred on the 1st April 1911.

PERSONNEL.

Imperial Officers.

Major H. H. Turner, R.E., in charge.
Lieutenant E. B. Cardew, R.E.
Lieutenant F. J. M. King, R.E.
Lieutenant H. G. Bell, R.E.
Lieutenant K. Mason, R.E., attached up to 31st March 1911.

Provincial Officers.

Mr. H. B. Simons, up to 31st May 1911.
Mr. C. H. Tresham.
Mr. Abdul Hai.
Mr. V. D. B. Collins.
Mr. F. W. Smith.
Mr. V. P. Wainright.
Mr. G. A. Norman.
Mr. B. T. Wyatt.
Mr. C. S. McInnes.
Mr. Abdul Karim.
Mr. K. S. Gopalachari.

In order that the work of the party may be properly controlled, the officer in charge now remains permanently at head-quarters instead of as formerly taking charge of one of the detachments.

The secondary triangulation was initiated in 1908. The object aimed at was to give more frequent checks to the minor triangulation than were afforded by the principal work, and to provide secondary permanent marks, which will be available in future years for resurveys of the country. Present day experience has shown that it is essential that other marks in addition to those of the principal triangulation should be permanently preserved. Districts which were surveyed 50 years ago are now being resurveyed, and owing to all traces of the old triangulation marks having vanished, the areas have to be re-triangulated. The ideal system would be to run secondary series along parallels one degree apart, closing them on principal meridional series two degrees apart. For the present it must however suffice to run these longitudinal secondary series according to the requirements of the topographical work; a commencement is to be made during the coming season in the Southern and Eastern Circles by running secondary series along parallels 12°, 19°, and 23°.

The secondary stations have been made square in section in order to distinguish them from principal stations, and they will be placed at distances from 10 to 20 miles apart.

When possible opaque signals will be employed, and in order to facilitate the pole being maintained in a perpendicular position, a hollow core, from 4 to

Photo-Engraved & printed at the Offices of the Survey of India, Calcutta,

G. T. S. SINGLENG BUM.

Upper Irrawaddy Series, Upper Burma.

6 inches in diameter and 1 foot deep, will be left in the centre of the pillar in which the signal post will be inserted and supported by wooden struts. There will be a markstone with the usual ⊙ at the base of this core. Should it be necessary to use a heliotrope or theodolite at any of these stations, it would be sufficiently accurate for topographical work to centre the heliotrope over the centre of the circle formed by the top of the core.

Of the three principal detachments one under Lieutenant Cardew continued the Upper Irrawaddy series in Upper Burma ; the expectation of connecting this series with the Mandalay meridional series this season has not been fulfilled ; but all stations that are likely to be utilized, have been built and provisionally fixed, and are available for use for topographical work. The actual connection must now be delayed until there is a prospect of the series being extended to the north-west to form a junction in Assam with the Indian triangulation. As there are some very large triangular errors in the two figures included between the sides Kumtung Bum—Löngre Bum and Singleng Bum—Kauhto Bum, re-observations of these figures should if possible be undertaken. Five of the triangles have an error exceeding 1″, and in one case it is nearly 3″. The correspondence relating to the errors has been bound with the computations of this season for easy reference, when the continuation of the series is undertaken. As the rays at the station Kauhto Bum are grazing ones, it will be advisable in a revision to reject this station and build a new one to the west of it. Some notes as to the proposed connection with the Mandalay series have also been bound with the computations of 1910-11.

The second principal detachment under Lieutenant King continued the Great Salween series in the Southern Shan States. As the work on this series has been stopped for the coming season, it should be noted that the best way of reaching Kengtung is by rail to Hsīpaw and thence by road using mule transport.

The third principal detachment continued the new Kashmīr series. Lieutenant Bell, who was in charge, had instructions to complete the triangulation as far as Gilgit only. This entailed observations at four stations and, although their average height reaches close on 16,000 feet and he had to descend to 3,000 feet between his ascents, he accomplished the work in a little under six weeks. On completion of the triangulation work, Messrs. Bell and Wainright were employed on reconnoitring to the north of Gilgit.

Their reconnaissances were undertaken for the purpose of selecting a route to carry the principal triangulation up to the Pāmirs and effect a junction with the Russian triangulation.

The results of their work prove that the extension of the principal work to the north will be impossible and that, if the Russian connection is made, it will have to be by means of secondary triangulation carried up the Hunza valley.

Of the secondary detachments one under Mr. Collins completed the Mawkmai Series in the Southern Shan States. The other two were employed in Assam. The one to the west, under Mr. Smith, triangulated through the Gāro Hills and the other to the east, under Mr. Abdul Hai, extended the Khāsi Hills series through the Jaintiā Hills.

During the summer of 1911 Messrs. Collins and Wyatt were employed in locating the position and fixing the height of the peak Teram Kangri which was thought by Dr. Longstaff to be an exceptionally high peak.

A description of the detail work of each detachment is given below :—

Abstract of work done.

		Stations.				Triangulation.		Triangular error.	Astronomical Azimuths observed.	Astronomical minus Geodetic Azimuth.
		Observed at.	Newly fixed.	Provisionally fixed.	Built.	Length in miles.	Area in square miles.			
Principal.	I—Upper Irrawaddy	8	4	4	5	80	1,760	0″·875 for 10 triangles.	1	—7″·02
	II—Great Salween	5	4	3	6	74	2,200	0″·753 for 9 triangles.	1	—7″·35
	III—Kashmir	4	4	2	2	64	680	0″·606 for 8 triangles.	...	...
Secondary.	V—Mawkmai	15	11	...	1	58	500	2″·44 for 8 triangles.	...	...
	VI—Gāro Hills	11	9	...	12	60	703	1″·57 for 6 triangles.	...	...
	VII—Jaintiā Hills	24	23	...	...	78	473	1″·36 for 23 triangles.	...	...

DETAILS OF PRINCIPAL TRIANGULATION.

I.—Upper Irrawaddy Series.—This detachment, under Lieutenant Cardew, arrived in Myitkyinā on the 30th October 1910. After a week's halt spent in making preparations Lieutenant Cardew crossed to the east bank of the Irrawaddy and reached Matu Bum, his first station, on November 16th.

At the second station Singleng Bum, some difficulty was experienced in building a station on this hill, as the highest point consisted of a large rock, on the top of which there was not sufficient room to pitch the observatory tent. Eventually, the station pillar was built on the highest point of the rock and a wooden platform was constructed round it.

At the next station Marau Bum, the ray to Kauhto Bum was a grazing one. In order to improve it the signal Kauhto Bum was raised by erecting a wooden trestle 15 feet high and placing the lamp on the top of it.

Bumdaw Bum, the seventh station was reached on the 4th of March. This was to have formed the north-west corner of the figure by which a junction was to be made with the Mandalay Meridional series. However, Mr. Abdul Karim on visiting Taungthonlon, one of the Mandalay series stations, found that pagodas had been erected to the north of the station effectually blocking out the ray to Bumdaw. As the question of demolishing these pagodas had to be referred to the Civil authorities, the completion of the junction of the two series had to be postponed to a future season.

No. III 12″ Micrometer theodolite by Troughton and Simms was used for all observations.

II.—The Great Salween Series.—This detachment under Lieutenant King, R.E., arrived at Thazi on the 21st October.

The march to Loi Lung, the station where Captain Browne had ceased operations in 1908-09, was made *viâ* Taunggyi and Takaw and occupied six weeks. Along the route lamp squads were detached to occupy the stations to the west of Loi Lung.

On the 14th of February, Lieutenant King arrived at the fifth station Loi Hsam Hsum. From this time onwards, great difficulty was experienced owing to the haze which had set in.

Escorts were required for all work east of the Salween River and these were supplied by the Officer Commanding Military Police at Loimwe.

No. II 12″ Micrometer theodolite by Troughton and Simms was used throughout the work.

III.—The Kashmīr Series.—The detachment assembled at Rāwalpindi on the 27th of April 1911 and then marched to Bāramūla, from thence proceeding to Bandipur by boat. Lieutenant Bell, who was in charge of the work, made Bandipur the head-quarters of his office. As it would have been difficult to obtain sufficient local transport, the Kashmīr authorities had been asked to obtain Balti coolies from Skārdu; 70 of these were assembled at Bandipur and 50 more met Mr. Wainwright in Gilgit.

Lieutenant Bell left Bandipur on 21st May and marched *viâ* Handwara and the Ladarwan pass into the Kishengangā Valley and then on to Rutha Pahar, snow lying there as low as 8,000 feet. As the hill is 14,800 feet high, great difficulty was experienced in establishing the lamp-squad on it. Chatiwala H. S. was the next objective and after placing the lamp-squad on this hill Lieutenant Bell proceeded *viâ* Niat to Liowi H. S., his first observation station.

Last year's report accounted for operations up to the end of August 1910; during September and October both forward and back observations were obtained at Rutha Pahar and the forward rays from Chatiwala were observed. These latter, owing to the difficulty of getting the 12″ theodolite to the top of the hill, were observed with an 8″ micrometer theodolite. At the time, it appeared that the 8″ theodolite would have to be used at other forward stations but so far, the 12″ theodolite has been carried to the tops of all the other stations and it is a matter for regret that the continuity of the work with this instrument has been broken by the work at Chatiwala.

Liowi, which is 17,480 feet high, is so far the highest station of the series. After establishing a base camp at 13,000 feet on June 12th, Lieutenant Bell reached the top the next day and commenced observations the same evening. The thermometer at this station showed a minimum temperature of 20 degrees Fahrenheit, and the strain of observing in this temperature and at this altitude was considerable.

Owing to bad weather the observations were not completed till the 21st June. The descent of the hill was made the same day and Zinghi Shish, the next station, was reached on the 23rd June. A few angles were observed the same day and then snow fell continuously till the 28th. The observations were however completed on the 22nd July. The portable lightning conductor, which was erected over the observatory tent was struck on one occasion at this station. On the way to Chamuri, the next station, a severe earthquake shock was experienced at Giñe, in the Indus valley, causing a cliff close by to be precipitated into the river. As a contrast to the extreme cold so lately experienced on the hills, the heat in the Indus Valley was so great that marching was only possible in the early morning and late evening. Chamuri was reached on the 8th July

and observations were at once commenced and with a slight interruption by snow on the 11th, were carried on uninterruptedly up to the 12th. On that day, the observations were completed and the descent to the base camp made. The detachment then marched *viâ* Damot and the Pahotc Nala to Gashu Shisb, arriving there on the 19th July. Up to the 23rd, cloudy and snowy weather were experienced during the day, though the nights were clear, rendering observations to lamps possible. The work was completed on the 26th. This concluded the programme of triangulation operations for the season, and Lieutenant Bell arrived at Gilgit with his detachment on the 28th July.

Mr. Wainright, who had been employed on building the forward stations of Bijhoo (on the slopes of Dubanni) and Dinaur, met Lieutenant Bell in Gilgit.

On the 1st August nearly all the khalasis under Babu Mahesha Nand started on their return journey to India. Lieutenant Bell and Mr. Wainright started the same day to carry out, respectively, reconnaissances of the Sakiz Jarab range and the Hunza valley with a view to the triangulation being carried by one of these routes to a junction with the Russian Triangulation. After completing their reconnaissances the two officers returned to Mussoorie arriving there on the 5th October.

IV.—Revision of Heights on the Great Arc Meridional Series.—It having been decided that a revision of the heights on this series south of parallel 24° was necessary, the work was entrusted to Mr. Bidhu Bhusan Shome.

The detachment arrived at the south end of the Sironj base line on the 20th January 1911 and observations were immediately started.

Observations were carried out at 12 principal stations and the heights of 10 old stations were revised. The revised heights are in all cases less than the old heights, the differences varying from 3 to 7 feet.

Three stations, which were found to have been destroyed, were rebuilt.

DETAILS OF SECONDARY TRIANGULATION.

V.—The Mawkmai Series.—The detachment under Mr. Collins arrived at Pyinmanā on the 21st October 1910. Mr. Collins left the detachment to march to Loi-Kaw and, himself, proceeded to Taunggyi to interview the Superintendent, Southern Shan States, and rejoined his detachment at Loi-Kaw.

Mr. Collins first visited Suletaung H. S. to observe the angles left unobserved the previous season; he was however unsuccessful in calling up the heliotropers posted at the stations Letpathaung and Le-Hpa-Antaung, and had to give up the observations of these stations; the work was carried out later in the season by Mr. Gopalachari, who was detached from the base line detachment for that purpose.

Mr. Collins then proceeded to fill in the gap in the series between the sides Loi-Mē-tē-yam—Loi Üngson and Loi Mawng—Loi Kang Mong. On completion of this Mr. Collins proceeded to the eastern extremity of the series and joined up the series with the side Loi Pakhan—Loi Tum of the Monghsat series.

An adjustment of the Mawkmai series triangulation between the Mandalay and Monghsat series has not been made, as the average triangular error of the latter series is greater than that of the Mawkmai series. The average triangular error of the Monghsat series is given in Annual Report of 1892-93 as 1″·9, whereas, if the computations are consulted, it will be found to exceed 3″.

VI.—The Gāro Hills Series.—This detachment under Mr. Smith arrived in Dhubri on the 14th October 1910.

The series emanates from the side Samding—Rangira of the Brahmaputra meridional series, and running east, was to make a junction with the Khāsi Hills series which had been observed in the previous season. It was hoped that the junction would give further data as to the amount of movement of the stations of the Eastern Frontier Series caused by the earthquake in 1897. Unfortunately Mr. Smith had to close work without effecting the junction.

Great delay was experienced in commencing observation work owing to Mr. Norman, who was detailed to build the advanced stations, falling ill. Mr. Smith had therefore to build the first few stations himself and then return and observe at them.

Mr. Smith commenced observations at Samding on the 8th January.

At the succeeding stations frequent delays were caused by the inclement weather, and towards the end of April nearly the whole of the detachment were ill with fever. Mr. Smith struggled on in the attempt to complete the junction with the Khāsi Hills series, but owing to the sickness and continued bad weather, he was obliged to give up the attempt.

A gap of some 20 miles between the two series consequently remains unobserved and this should be observed at the earliest opportunity.

VII.—The Jaintiā Hills Series.—Mr. Abdul Hai, who was in charge of this detachment, was employed during the hot weather in work in Kashmīr, so that the detachment did not arrive at Gauhāti till November 18th, 1910.

The series was an extension to the east of the Khāsi Hills series, and as the stations had been built in season 1909-10, Mr. Abdul Hai had only the observing work to do.

The series is based on the side Laidera—Dinghei of the Eastern Frontier meridional series and extends along parallel 25° 30′ from meridian 91° 50′ to meridian 93°. Up to the Kāpili river, the country consists of hills covered with trees from 80 to 100 feet high; after this, dense bamboo jungle is encountered.

TRIANGULATION TO FIX THE POSITION AND HEIGHT OF TERAM KANGRI.

Dr. Longstaff, in his explorations in Kashmīr in 1909, discovered what he considered to be a very high peak; he located this peak approximately in latitude 35° 38′ 30″ and in longitude 77° 7′ 30″.

A detachment under Mr. Collins was sent to Leh with instructions to see if the peak was visible from any of Montgomerie's stations in that neighbourhood; and if not, to run a short series of triangulation, northwards, based on a side of Montgomerie's series until the peak became visible.

Mr. Collins arrived in Leh early in June and proceeded to visit the stations Tayār and Arzū of Montgomerie's series, while Mr. Wyatt went to Pachuspha, Himis, Pārchākanri and Lasirmau, but neither officer succeeded in obtaining a view of Teram Kangri. Mr. Collins consequently decided to make a reconnaissance up the Nubra Valley, leaving Mr. Wyatt to bring up the triangulation.

Mr. Collins first attempted to climb Skanpuk H. S., 20,288 feet, but owing to recent falls of heavy snow, he could not reach the top, though later in the season, he made the ascent and took observations from it. He then proceeded

up the Nubra Valley, visiting peaks on both sides of the river. The first sight of Teram Kangri was obtained from Wasak station, and observations were later on obtained from Ningstet, Strongstet and Tiggur. The distances of these stations from Teram Kangri vary from 39 to 69 miles.

The work has been finally based on Skanpuk—Peak 3 (Shyok Watershed)—See Synoptical Volume VII. These two peaks are intersected points of triangulation executed in the year 1861. It is unfortunate that the triangulation could not be based on Montgomerie's series but, owing to Peak 3 being inaccessible and the intersections to it having been made by two separate observers, it has been thought better to accept the old values for that peak, rather than that obtained from the present triangulation. If possible, Mr. Collins will close his work on Montgomerie's series next year. The work is sufficiently accurate to establish without doubt the position and height of Teram Kangri.

The position of Teram Kangri computed from Mr. Collins' observations is Latitude 35° 34′ 37″, Longitude 77° 07′ 31″ and its mean height 24,489 feet, using a coefficient of refraction of 0·035.

The following are the results of the heights obtained from the vertical angles taken from the four stations of observation :—

	feet.
From Ningstet	24,473
„ Tiggur	24,544
„ Strongstet	24,442
„ Wasak	24,496
Mean	24,489

In executing the work Mr. Collins climbed to the top of 16 peaks of over 19,000 feet and Mr. Wyatt climbed 7 peaks of over 19,000 feet.

BASE-LINE RECONNAISSANCE.

The detachment arrived in Myitkyna on the 28th October 1910, but Mr. McInnes, who was in charge of the work, did not arrive till the 7th November, having been employed on work in Kashmīr during the hot weather.

On the 12th November Mr. McInnes commenced reconnoitring the surrounding plain, but owing to the numerous large swamps no suitable site could be found.

On the 1st December the detachment moved on to Bhamo and a site was finally selected between the Taping Chaung and the Mole Chaung.

The length of the line selected is about 8 miles. The forest has been cleared along the line to a width of 10 feet and pillars 1½ feet square and 1 foot high, have been built along the line at intervals of about 1 mile. A dot on the top of each pillar marks the actual line. The pillars are so placed that from each of the intermediate pillars at least one forward and one back pillar is visible. The ends as at present situated are not intervisible. The line can easily be connected to the surrounding principal triangulation.

On the completion of the work at Bhamo, Mr. Gopalachari, who had assisted Mr. McInnes, proceeded to the Southern Shan States to carry out observations at a station on the Mawkmai series which had unavoidably been omitted.

Mr. McInnes, with the other half of the detachment, proceeded to Toungoo on the 21st February and after reconnoitring the country there, went on to Prome.

At Prome he selected a line about 13 miles long and prepared it in the same manner as that at Bhamo. The ends of this line, as set out, are intervisible.

It is probable that the line prepared at Bhamo will not be suitable, and a further reconnaissance in Upper Burma will have to be made to select a more favourable site.

Indo-Russian Triangulation.

The question of the connection of the Indian and Russian triangulation was first discussed at the International Geodetic Conference sitting in London in the year 1909. The route suggested for the connection was through Kashmīr and the Russian Pāmirs. The actual request for the work to be initiated by Indian triangulators was not received by the Surveyor General of India until the early part of the year 1911.

On the Russian side, the work of bringing their triangulation south was commenced in June 1910 by Lieutenant-Colonel Tchekine from the base Ourtak-Tchoucour—Machali-Goudour, approximately in latitude 39°33′ situated on the northern slope of the Trans-Alai chain of mountains. During 1910, he carried his triangulation down to the Pāmir post, approximately to latitude 38°13′. During the summer of 1911, the triangulation has been extended to the Russian frontier, and two stations Beyik, 15,078 feet, approximate latitude 37°18′, approximate longitude 75°7′ and Taghramansu, approximate latitude 37°16′, approximate longitude 74°54′, have been fixed; it now remains for the Indian triangulators to close their work on these two stations.

Owing to the necessity of first making a reconnaissance towards the Pāmirs, the work on the actual Kashmīr principal triangulation was curtailed during 1911 but nevertheless, Lieutenant Bell has extended the work northwards to just south of parallel 36°.

The Surveyor General had asked that Concord Peak and Salisbury Peak on the Russo-Afghān Frontier might be fixed by the Russian triangulators, so that they might be observed from stations selected on the Sakiz Jarab range. Lieutenant Bell, however, reports in his reconnaissance that the peaks of the Sakiz Jarab range are inaccessible, and on the Russian side a report has been received that Concord Peak, owing to the view to the south being entirely shut off by higher ranges, is unsuitable. This being the case this method of forming the junction of the two triangulations has been abandoned.

Mr. Wainright who made a reconnaissance up the Hunza Valley reports that it will be possible by means of short-sided triangles to carry the triangulation from parallel 36° up the Hunza Valley to the Kilik Pass. The two most northerly stations suggested by General Lieutenant Pomerantzeff (of the Russian General Staff) for the Indian triangulators, are the Kilik pass 15,600 feet, approximate latitude 37°5′, approximate longitude 74°43′ and the Mintaka pass, 15,430 feet, approximate latitude 37°2′, approximate longitude 74°57′. Judging from the work carried out by Mr. Wainright, there should be no difficulty in bringing the Indian triangulation up to these stations.

The Indian triangulation up to parallel 36° is of the highest degree of accuracy; all stations, with the exception of the forward rays at one, having been observed with a 12″ micrometer theodolite. In carrying it on up the

Hunza Valley the sides of the triangles will have to be considerably shortened and the work will probably have to be done with an 8″ micrometer theodolite and the accuracy of the work considerably reduced. Observations will be taken on six zeros with four measures on each zero, and whether luminous or opaque signals are used in the work, the assurance can be given that the work will be of the very best secondary class, and will equal in quality that of the Russian triangulation, as extended from their base north of the Trans-Alai Mountains.

The question arises, will this secondary work be of sufficient geodetic value o satisfy the International Geodetic Conference, and if not, is there any possibility of making a better connection between the Russian and Indian triangulations. Afghānistān extending all along the North-West Frontier of India presents at present an impassable barrier. We have therefore to turn to the far western corner, where the Indian triangulation extends to the Persian frontier. By carrying the triangulation over this frontier along parallel 29°, it might be brought to a point south of the Russian Caspian triangulation, and it would be a simple matter, provided the country is favourable, for the Russians to run a series due south to meet this proposed western extension of the Indian triangulation.

REPORT OF RECONNAISSANCE FOR THE PROPOSED CONNECTION WITH RUSSIA.

BY LIEUT. H. G. BELL, R.E.

The Darkot pass was first visited by way of the Yāsin Valley, with a view to examining the peaks in its vicinity. The pass itself consists of a formidable glacier much intersected by crevasses and is only passable early in the morning. It was hoped that peak 19,369 feet, west of the pass, might prove suitable for a station; but it was found to be quite inaccessible for survey purposes. The surrounding and lower peaks, in addition to being practically inaccessible, would have been useless owing to higher and inaccessible peaks to the south and south-east.

From Darkot, the valley leading to Garmush 20,564 feet was visited; all the valleys leading to the foot of this mountain are blocked by dangerous glaciers, and the slopes of the mountain are so precipitous that the snow does not remain on them, hence it was considered impracticable for a station. Then the Darkot-Askuman Pass was crossed and a peak to the south ascended and a further view of the Garmush and other peaks of the Sakiz Jarab range obtained. The whole range consists of nothing but extremely sharp and precipitous peaks, while south of it between the Yāsin and Karumbar Valleys there are many high peaks unmarked on the existing map.

Since the physical features of the country made it impossible to select suitable stations for a principal series east of the Darkot Pass, a move was made to the Karumbar Valley in the hopes of being able to find a way through in this direction. The valley is wide and bordered by moderately high and accessible peaks as far as Imit or Harmat, but from here northwards, the valley closes in and the mountains rise precipitously from the river bed; there is no way along the western bank and progress in that direction is further barred by a landslip which discharges rocks and earth into the river night and day. It was impossible at the time of year to penetrate further up the valley than the Karumbar glacier, for the road which crosses and re-crosses the river was impassable owing to the river being in flood. However, as the whole valley had

not been reconnoitred, it was decided to make a second attempt when the river subsided ; in the meanwhile news was received that a feasible route had been found up the Hunza river, so as it was getting late in the season, further reconnaissance was abandoned.

HUNZA VALLEY RECONNAISSANCE.

BY MR. V. P. WAINRIGHT.

Owing to the high and inaccessible peaks that border the valley on either side, it was found necessary to keep as close as possible to the main watercourse ; the whole length of the river was thus followed from Gilgit to the Kilik pass, approximately 170 miles.

The base at the pass was first selected from where the view was extensive, especially northwards towards Russia, where peaks 150 miles off were visible. This part being uninhabited except for shepherds, it was impossible to obtain coolies, and consequently the next four stations were not visited ; but being prominent peaks were fixed from surrounding stations. Owing to this difficulty it would be advisable not to follow the Hunza river further than Misgar, the last village met with on the Gilgit-Pāmir route, but continue up the Khungarah river towards the Kharchanai pass, which appeared to be easy country in comparison to that between Misgar and the Kilik pass.

All the peaks that have been fixed are easy and lie between 8,000 and 17,000 feet. The two highest being those of the Kilik base.

The road between Hunza and Misgar is extremely bad and it would be practically impossible to take any large instrument along it ; the worst bit is between Attabad and Gulmit where sheer cliffs have to be crossed on wooden beams placed along the face of cliffs and supported by iron pegs driven into the rock.

PART IV.—TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index map 10).

BY MAJOR J. M. BURN, R.E.

PERSONNEL.

Imperial Officers.

Mr. C. F. Erskine, in charge up to 14th October 1910,

Major J. M. Burn, R.E., in charge from 15th to 26th October 1910, and again from 27th November 1910.

Provincial Officers.

Mr. H. G. Shaw, in charge from 27th October to 26th November 1910.

Mr. Syed Zille Hasnain.

During the past year tidal registrations by self-registering tide-gauges were recorded at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. In addition, tide-pole readings of high and low water were taken during daylight at the ports of Bhāvnagar, Akyab and Chittagong, with the object of comparing the actual times and heights with the predictions. From 1st January 1911 the tide-pole readings at the port of Chittagong were discontinued, and in their place the readings of the diagrams recorded on a small self-registering tide-gauge erected by the port authorities have been utilised.

All the observations were made under the direction of this department and under the immediate control of the Port Officers concerned.

The reduction by harmonic analysis of the observations for 1910 of the 9 stations named above has been completed. The tide-tables for 1912 have arrived in India and have been distributed. The work of publication of the tide-tables for 40 ports for the year 1914 is in progress in England. Data for these predictions were despatched from this office in January 1911.

LIST OF TIDAL STATIONS.

The following table gives a list of the 42 ports at which tidal observations have been registered, together with the periods of observation from 1874, when tidal operations were commenced, up to the present time. The stations shown in italics are permanent; the others are minor stations which were closed on the completion of the requisite registrations.

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez	Automatic	1897	1903	7	
2	Perim	Ditto	1898	1902	5	
3	*Aden*	Ditto	1879	Still working	32	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karāchi*	Ditto	1868 1881	1880 Still working	*13 31 } 44	* Small Tide-Gauge working.
7	Hanstal	Ditto	1874	1875	1	Tide-Tables not published.
8	Navānāi	Ditto	1874	1875	1	Ditto.
9	Okhā Point	Ditto	1874 Re-started 1904	1875 1906	1 1 } 2	Year 1904-05 is excluded.
10	Porbandar	Personal	1893	1894	2	

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
10A	Porbandar . .	Automatic .	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kāthiāwār).	Personal .	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār).	Automatic .	1900	1903	4	
12	Bhāvnagar . .	Ditto .	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto .	1878	Still working	33	
14	*Bombay (Prince's Dock).*	Ditto .	1888	Still working	23	Property of Port Trust.
15	Marmagao (Goa) .	Ditto	1884	1889	5	
16	Kārwār . . .	Ditto .	1878	1883	5	
17	Beypore . .	Ditto .	1878	1884	6	
18	Cochin . . .	Ditto .	1886	1892	6	
19	Tuticorin . . .	Ditto .	1888	1893	5	
20	Minicoy . . .	Ditto .	1891	1896	5	
21	Galle . . .	Ditto .	1884	1890	6	
22	Colombo . .	Ditto	1884	1890	6	
23	Trincomalee . .	Ditto .	1890	1896	6	
24	Pāmban Pass . .	Ditto .	1878	1882	4	
25	Negapatam . .	Ditto .	1881	1888	5	Years 1883-1884, 1885 are excluded.
26	*Madras* . .	Ditto .	1880 Re-started 1895	1890 Still working	10 16 } 26	
27	Cocanāda . .	Ditto .	1886	1891	5	
28	Vizagapatam . .	Ditto .	1879	1885	6	
29	False Point . .	Ditto .	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto .	1881	1886	5	
31	Diamond Harbour .	Ditto .	1881	1886	5	
32	*Kidderpore* . .	Ditto .	1881	Still working	30	
33	Chittagong . .	Ditto .	1886	1891	5	
34	Akyab . . .	Ditto .	1887	1892	5	
35	Diamond Island .	Ditto .	1895	1899	5	
36	Bassein (Burma) .	Ditto	1902	1903	2	
37	Elephant Point .	Ditto .	1880 Re-started 1884	1881 1888	5	Year 1880-81 is excluded.
38	*Rangoon* . .	Ditto .	1880	Still working	31	
39	Amherst . .	Ditto .	1880	1886	6	
40	*Moulmein* . .	Ditto .	1880 Re-started 1909	1886 Still working	6 2 } 8	
41	Mergui . . .	Ditto .	1889	1894	5	
42	*Port Blair* . . .	Ditto .	1880	Still working	31	

WORKING OF THE OBSERVATORIES.

The nine tidal observatories now working were inspected during the year by Mr. Syed Zille Hasnain.

Aden.—As mentioned in last year's report the communication hole at the bottom of the float cylinder had become too large. It was therefore removed during this year's inspection, and a new cylinder which was made by the Port Engineer was fixed in its place. The tide-gauge was found to have worked satisfactorily since the last inspection. It was thoroughly cleaned and overhauled.

Karāchi.—This observatory was found in good order. The communication hole at the bottom of the cylinder was partially blocked by barnacles. It was thoroughly cleaned and the tide-gauge was overhauled and left in working order. There have been no breaks in the tidal registrations during the year.

Apollo Bandar (Bombay).—This observatory has worked well throughout the year. There was one minor interruption in the registration of the tide-gauge.

Prince's Dock (Bombay).—There have been a few short interruptions in the registration of the tide-gauge at this observatory owing to the pencil wire breaking.

Madras.—As the sluice at the bottom of the well of this observatory through which communication between the sea and the well is regulated had not been working satisfactorily for the past two years, steps were taken during this year's inspection to have it removed and replaced by a new one. This work took some days, and the registrations of the tide-gauge were consequently stopped from the 10th to the 21st February 1911. Opportunity was also taken to have the well thoroughly cleaned and repaired. With the exception of the above break, there have been no interruptions in the tidal registrations during the year. The old entrance to the harbour which was immediately south of the observatory has now been closed, and a new entrance has been made in the north arm of the harbour.

Kidderpore.—The tide-gauge at this observatory has worked well throughout the year. There was only one interruption of a few hours in the registrations owing to the stoppage of the driving clock. The inspecting officer found that a good deal of mud had collected near the bottom of the cylinder which was likely to interfere with free communication between the sea and the cylinder. The matter having been brought to the notice of the Deputy Conservator of the Port, the necessary dredging was carried out.

Rangoon.—There have been no breaks in the registrations of the tide-gauge at this observatory during the year. The tide-gauge and the auxiliary instruments were thoroughly cleaned and put in order.

Moulmein.—The tide-gauge at this observatory has worked well during the year, except for a few minor interruptions in its registrations owing to the stoppage of the driving clock. The inspecting officer found the graduated staff inaccurately divided. It was therefore removed and a new graduated staff was prepared and fixed in place of the old one.

Port Blair.—There has been only one interruption of a few hours in the registrations of the tide-gauge at this observatory owing to the stoppage of the driving clock. During the inspection the zero of the graduated staff was found

to differ by 0·1 of a foot from the zero of the tide-gauge. The staff was removed and refixed in its proper position so that its zero is now identical with the zero of the gauge.

TIDAL DIAGRAMS AND DAILY REPORTS.

The tidal diagrams and daily reports have been submitted regularly to the office of this party by the various port officials concerned.

TIDAL CONSTANTS.

The tidal observations at the nine working stations for the year 1910 have been reduced, and the tabulated values of the tidal constants thus determined are appended. There are no arrears.

The following tables give the amplitudes (R) and the epochs (ζ) deduced from the 1910 observations at the various stations; they also give the values of H and κ which are connected with R and ζ in such a way, through the various astronomical quantities involved in the positions of the sun and moon, that if the tidal observations were consistent from year to year H and κ would come out the same from each year's reductions.

ADEN, 1910.

Short Period Tides.

A_0=5·836 feet.

S_1	$H = R =$	·095	M_6	$R =$	·007	Q_1	$R =$	·139	T_2	$R =$	·049
	$\kappa = \zeta =$	178°·73		$\zeta =$	329°·20		$\zeta =$	132°·69		$\zeta =$	290°·68
S_2	$H = R =$	·685		$H =$	·007		$H =$	·125		$H =$	·049
	$\kappa = \zeta =$	241°·96		$\kappa =$	311°·63		$\kappa =$	45°·36		$\kappa =$	291°·94
S_4	$H = R =$	·002	M_8	$R =$	·001	L_2	$R =$	·017	$(MS)_4$	$R =$	·010
	$\kappa = \zeta =$	262°·88		$\zeta =$	74°·75		$\zeta =$	44°·53		$\zeta =$	246°·41
S_6	$H = R =$	·004		$H =$	·001		$H =$	·021		$H =$	·010
	$\kappa = \zeta =$	211°·19		$\kappa =$	291°·32		$\kappa =$	219°·95		$\kappa =$	120°·55
S_8	$H = R =$	·001	O_1	$R =$	·728	N_2	$R =$	·417	$(2SM)_2$	$R =$	·007
	$\kappa = \zeta =$	128°·66		$\zeta =$	343°·04		$\zeta =$	128°·74		$\zeta =$	300°·51
				$H =$	·652		$H =$	·425		$H =$	·007
				$\kappa =$	36°·60		$\kappa =$	221°·99		$\kappa =$	66°·37
M_1	$R =$	·076	K_1	$R =$	1·397	λ_2	$R =$	...	$2N_2$	$R =$	·079
	$\zeta =$	28°·12		$\zeta =$	210°·38		$\zeta =$	...		$\zeta =$	221°·29
	$H =$	·039		$H =$	1·302		$H =$	...		$H =$	·080
	$\kappa =$	73°·29		$\kappa =$	33°·77		$\kappa =$	...		$\kappa =$	173°·64
M_2	$R =$	1·515	K_2	$R =$	·226	ν_2	$R =$	·108	$(M_2N)_4$	$R =$	·008
	$\zeta =$	351°·27		$\zeta =$	53°·72		$\zeta =$	300°·04		$\zeta =$	247°·09
	$H =$	1·546		$H =$	·191		$H =$	·110		$H =$	·008
	$k =$	225°·41		$\kappa =$	239°·92		$\kappa =$	191°·01		$\kappa =$	214°·49
M_3	$R =$	·016	P_1	$R =$	·420	μ_2	$R =$	·069	$(M_2K_1)_3$	$R =$	·015
	$\zeta =$	201°·94		$\zeta =$	223°·50		$\zeta =$	64°·76		$\zeta =$	37°·33
	$H =$	·016		$H =$	·420		$H =$	·072		$H =$	·015
	$\kappa =$	193°·16		$\kappa =$	33°·37		$\kappa =$	173°·05		$\kappa =$	94°·87
M_4	$R =$	·006	J_1	$R =$	·081	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·004
	$\zeta =$	160°·91		$\zeta =$	66°·02		$\zeta =$	...		$\zeta =$	54°·64
	$H =$	·006		$H =$	·073		$H =$	...		$H =$	·004
	$\kappa =$	269°·19		$\kappa =$	27°·50		$\kappa =$	...		$\kappa =$	339°·53

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·023	263°·46	·025	44°·35
„ Fortnightly „	·075	69°·57	·059	16°·59
Luni-Solar „ „ . .	·009	336°·15	·009	102°·00
Solar-Annual „	·309	85°·65	·309	5°·78
„ Semi-Annual „	·086	281°·73	·086	122°·00

KARĀCHI, 1910.

Short Period Tides.

$A_0 = 7.233$ feet.

S_1	$H = R =$	·095	M_6	$R =$	·044	Q_1	$R =$	·143	T_2	$R =$	·087
	$\kappa = \zeta =$	188°·94		$\zeta =$	225°·61		$\zeta =$	142°·58		$\zeta =$	10°·68
S_2	$H = R =$	·973		$H =$	·047		$H =$	·128		$H =$	·087
	$\kappa = \zeta =$	322°·68		$\kappa =$	212°·52		$\kappa =$	57°·59		$\kappa =$	12°·00
S_4	$H = R =$	·011	M_8	$R =$	·005	L_2	$R =$	·033	$(MS)_4$	$R =$	·035
	$\kappa = \zeta =$	4°·12		$\zeta =$	31°·87		$\zeta =$	103°·95		$\zeta =$	83°·13
S_6	$H = R =$	·007		$H =$	·006		$H =$	·040		$H =$	·036
	$\kappa = \zeta =$	317°·29		$\kappa =$	254°·41		$\kappa =$	280°·07		$\kappa =$	318°·77
S_8	$H = R =$	·002	O_1	$R =$	·740	N_2	$R =$	·607	$(2SM)_2$	$R =$	·011
	$\kappa = \zeta =$	74°·06		$\zeta =$	352°·38		$\zeta =$	185°·40		$\zeta =$	333°·67
				$H =$	·662		$H =$	·619		$H =$	·011
				$\kappa =$	47°·50		$\kappa =$	280°·94		$\kappa =$	98°·04
M_1	$R =$	·090	K_1	$R =$	1·430	λ_2	$R =$	...	$2N_2$	$R =$	·115
	$\zeta =$	36°·56		$\zeta =$	223°·06		$\zeta =$	...		$\zeta =$	295°·35
	$H =$	·046		$H =$	1·333		$H =$	...		$H =$	·118
	$\kappa =$	82°·48		$\kappa =$	46°·39		$\kappa =$	...		$\kappa =$	250°·79
M_2	$R =$	2·586	K_2	$R =$	·315	ν_2	$R =$	·163	$(M_2N)_4$	$R =$	·019
	$\zeta =$	58°·83		$\zeta =$	134°·56		$\zeta =$	353°·75		$\zeta =$	27°·82
	$H =$	2·590		$H =$	·266		$H =$	·166		$H =$	·020
	$\kappa =$	294°·46		$\kappa =$	320°·64		$\kappa =$	246°·91		$\kappa =$	358°·99
M_3	$R =$	·035	P_1	$R =$	·409	μ_2	$R =$	·070	$(M_2K_1)_3$	$R =$	·013
	$\zeta =$	352°·30		$\zeta =$	235°·40		$\zeta =$	130°·91		$\zeta =$	51°·82
	$H =$	·036		$H =$	·409		$H =$	·073		$H =$	·013
	$\kappa =$	345°·76		$\kappa =$	45°·32		$\kappa =$	242°·19		$\kappa =$	110°·79
M_4	$R =$	·014	J_1	$R =$	·077	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·029
	$\zeta =$	208°·10		$\zeta =$	82°·64		$\zeta =$	...		$\zeta =$	64°·26
	$H =$	·015		$H =$	·069		$H =$	...		$H =$	·028
	$\kappa =$	319°·37		$\kappa =$	43°·26		$\kappa =$	...		$\kappa =$	352°·20

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·018	138°·97	·019	279°·07
„ Fortnightly „	·046	75°·51	·036	20°·91
Luni-Solar „ „	·011	356°·43	·011	120°·79
Solar-Annual „	·137	168°·26	·137	88°·33
„ Semi-Annual „	·147	329°·85	·147	170°·00

BOMBAY (APOLLO BANDAR), 1910.

Short Period Tides.

A_0 = 10·204 feet.

S_1	H = R =	·062	M_6	R =	·016	Q_1	R =	·139	T_2	R =	·163
	κ = ζ =	196°·78		ζ =	26°·57		ζ =	145°·18		ζ =	44°·97
S_2	H = R =	1·555		H =	·017		H =	·125		H =	·163
	κ = ζ =	2°·30		κ =	14°·66		κ =	60°·82		κ =	46°·31
S_4	H = R =	·014	M_8	R =	·009	L_2	R =	·016	$(MS)_4$	R =	·085
	κ = ζ =	251°·31		ζ =	114°·57		ζ =	332°·77		ζ =	146°·35
S_6	H = R =	·002		H =	·010		H =	·019		H =	·086
	κ = ζ =	190°·31		κ =	338°·70		κ =	149°·07		κ =	22°·38
S_8	H = R =	·002	O_1	R =	·721	N_2	R =	·949	$(2SM)_2$	R =	·036
	κ = ζ =	115°·46		ζ =	352°·78		ζ =	218°·37		ζ =	334°·00
				H =	·645		H =	·969		H =	·037
				κ =	48°·31		κ =	314°·52		κ =	97°·97
M_1	R =	·094	K_1	R =	1·496	λ_2	R =	...	$2N_2$	R =	·118
	ζ =	35°·39		ζ =	221°·68		ζ =	...		ζ =	334°·56
	H =	·048		H =	1·394		H =	...		H =	·120
	κ =	81°·50		κ =	45°·00		κ =	...		κ =	290°·82
M_2	R =	3·853	K_2	R =	·481	ν_2	R =	·240	$(M_2N)_4$	R =	·017
	ζ =	93°·96		ζ =	171°·68		ζ =	23°·08		ζ =	240°·91
	H =	3·934		H =	·407		H =	·245		H =	·018
	κ =	329°·99		κ =	357°·73		κ =	276°·82		κ =	213°·09
M_3	R =	·074	P_1	R =	·404	μ_2	R =	·205	$(M_2K_1)_3$	R =	·087
	ζ =	23°·12		ζ =	234°·98		ζ =	181°·08		ζ =	148°·61
	H =	·076		H =	·404		H =	·214		H =	·083
	κ =	17°·16		κ =	44°·92		κ =	293°·14		κ =	207°·96
M_4	R =	·082	J_1	R =	·080	R_2	R =	...	$(2M_2K_1)_3$	R =	·064
	ζ =	187°·34		ζ =	88°·64		ζ =	...		ζ =	135°·07
	H =	·085		H =	·072		H =	...		H =	·062
	κ =	299°·41		κ =	49°·03		κ =	...		κ =	63°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·009	334°·26	·010	114°·14
„ Fortnightly „	·043	73°·05	·034	18°·03
Luni-Solar „ „	·024	251°·94	·025	15°·91
Solar-Annual „	·057	41°·04	·057	324°·10
„ Semi-Annual „	·135	357°·13	·135	197°·25

BOMBAY (PRINCE'S DOCK), 1910.

Short Period Tides.

A_0 = 8·201 feet.

S_1	H = R =	·085	M_6	R =	·012	Q_1	R =	·143	T_2	R =	·167
	κ = ζ =	190°·85		ζ =	219°·14		ζ =	145°·74		ζ =	45°·00
S_2	H = R =	1·594		H =	·013		H =	·128		H =	·167
	κ = ζ =	5°·58		κ =	207°·24		κ =	61°·38		κ =	46°·34
S_4	H = R =	·020	M_8	R =	·002	L_2	R =	·023	$(MS)_4$	R =	·117
	κ = ζ =	218°·21		ζ =	198°·44		ζ =	10°·73		ζ =	168°·09
S_6	H = R =	·004		H =	·003		H =	·028		H =	·120
	κ = ζ =	181°·51		κ =	62°·56		κ =	187°·02		κ =	44°·12
S_8	H = R =	·002	O_1	R =	·735	N_2	R =	·968	$(2SM)_2$	R =	·041
	κ = ζ =	184°·76		ζ =	353°·23		ζ =	221°·49		ζ =	352°·38
				H =	·657		H =	·989		H =	·041
				κ =	48°·76		κ =	317°·63		κ =	116°·35
M_1	R =	·101	K_1	R =	1·504	λ_2	R =	...	$2N_2$	R =	·109
	ζ =	35°·00		ζ =	222°·38		ζ =	...		ζ =	338°·12
	H =	·052		H =	1·402		H =	...		H =	·111
	κ =	81°·11		κ =	45°·70		κ =	...		κ =	204°·38
M_2	R =	3·958	K_2	R =	·497	ν_2	R =	·234	$(M_2N)_4$	R =	·007
	ζ =	96°·41		ζ =	175°·95		ζ =	23°·94		ζ =	124°·38
	H =	4·041		H =	·421		H =	·239		H =	·008
	κ =	332°·44		κ =	2°·00		κ =	276°·67		κ =	96°·56
M_3	R =	·077	P_1	R =	·409	μ_2	R =	·211	$(M_2K_1)_3$	R =	·091
	ζ =	28°·68		ζ =	235°·76		ζ =	188°·58		ζ =	136°·10
	H =	·079		H =	·409		H =	·220		H =	·086
	κ =	22°·68		κ =	45°·70		κ =	300°·65		κ =	195°·45
M_4	R =	·087	J_1	R =	·082	R_2	R =	...	$(2M_2K_1)_3$	R =	·081
	ζ =	225°·10		ζ =	87°·97		ζ =	...		ζ =	150°·44
	H =	·091		H =	·074		H =	...		H =	·078
	κ =	337°·16		κ =	48°·36		κ =	...		κ =	79°·18

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·016	265°·64	·017	45°·53
„ Fortnightly „	·051	77°·07	·040	22°·04
Luni-Solar „ „	·041	247°·61	·042	11°·57
Solar-Annual „	·053	50°·11	·053	330°·17
„ Semi-Annual „	·146	353°·48	·146	193°·60

MADRAS, 1910.

Short Period Tides.

A_0 = 2·412 feet.

S_1	$H = R =$	·030	M_6	$R =$	·003	Q_1	$R =$	·002	T_2	$R =$	·028
	$\kappa = \zeta =$	94°·90		$\zeta =$	151°·70		$\zeta =$	113°·20		$\zeta =$	319°·15
S_2	$H = R =$	·461		$H =$	·004		$H =$	·001		$H =$	·028
	$\kappa = \zeta =$	269°·76		$\kappa =$	141°·30		$\kappa =$	29°·63		$\kappa =$	320°·51
S_4	$H = R =$	·001	M_8	$R =$	·001	L_2	$R =$	·017	$(MS)_4$	$R =$	·004
	$\kappa = \zeta =$	345°·96		$\zeta =$	257°·47		$\zeta =$	93°·24		$\zeta =$	79°·29
S_6	$H = R =$	·002		$H =$	·001		$H =$	·056		$H =$	·004
	$\kappa = \zeta =$	81°·03		$\kappa =$	123°·61		$\kappa =$	269°·76		$\kappa =$	315°·82
S_8	$H = R =$	·001	O_1	$R =$	·106	N_2	$R =$	·233	$(2SM)_2$	$R =$	·020
	$\kappa = \zeta =$	23°·96		$\zeta =$	268°·37		$\zeta =$	140°·52		$\zeta =$	106°·47
				$H =$	·095		$H =$	·238		$H =$	·020
				$\kappa =$	324°·42		$\kappa =$	237°·44		$\kappa =$	229°·94
M_1	$R =$	·007	K_1	$R =$	·324	λ_2	$R =$	...	$2N_2$	$R =$	·043
	$\zeta =$	354°·45		$\zeta =$	152°·75		$\zeta =$	...		$\zeta =$	253°·60
	$H =$	·004		$H =$	·302		$H =$	...		$H =$	·044
	$\kappa =$	40°·81		$\kappa =$	336°·05		$\kappa =$	...		$\kappa =$	210°·90
M_2	$R =$	1·053	K_2	$R =$	·148	ν_2	$R =$	·061	$(M_2N)_4$	$R =$	·003
	$\zeta =$	4°·31		$\zeta =$	84°·91		$\zeta =$	312°·26		$\zeta =$	151°·82
	$H =$	1·075		$H =$	·126		$H =$	·063		$H =$	·004
	$\kappa =$	240°·85		$\kappa =$	270°·92		$\kappa =$	206°·73		$\kappa =$	125°·28
M_3	$R =$	·003	P_1	$R =$	·096	μ_2	$R =$	·040	$(M_2K_1)_3$	$R =$	·010
	$\zeta =$	52°·70		$\zeta =$	168°·16		$\zeta =$	54°·89		$\zeta =$	86°·39
	$H =$	·003		$H =$	·096		$H =$	·041		$H =$	·009
	$\kappa =$	47°·50		$\kappa =$	338°·12		$\kappa =$	167°·96		$\kappa =$	146°·22
M_4	$R =$	·003	J_1	$R =$	·013	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·002
	$\zeta =$	94°·40		$\zeta =$	215°·13		$\zeta =$	...		$\zeta =$	28°·07
	$H =$	·003		$H =$	·012		$H =$	...		$H =$	·002
	$\kappa =$	207°·47		$\kappa =$	175°·23		$\kappa =$	...		$\kappa =$	317°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·058	218°·58	·063	358°·19
„ Fortnightly „	·055	48°·04	·043	352°·48
Luni-Solar „ „	·024	21°·15	·025	144°·61
Solar-Annual „	·504	278°·46	·504	198°·49
„ Semi-Annual „	·235	267°·78	·235	107°·85

KIDDERPORE, 1910.

Short Period Tides.

A_0 = 10·895 feet.

S_1	$H = R =$	·090	M_6	$R =$	·165	Q_1	$R =$	·016	T_2	$R =$	·203
	$\kappa = \zeta =$	192°·21		$\zeta =$	321°·19		$\zeta =$	100°·01		$\zeta =$	156°·39
S_2	$H = R =$	1·553		$H =$	·175		$H =$	·014		$H =$	·203
	$\kappa = \zeta =$	95°·61		$\kappa =$	312°·43		$\kappa =$	17°·31		$\kappa =$	157°·77
S_4	$H = R =$	·107	M_8	$R =$	·080	L_2	$R =$	·168	$(MS)_4$	$R =$	·693
	$\kappa = \zeta =$	106°·65		$\zeta =$	28°·89		$\zeta =$	232°·54		$\zeta =$	194°·29
S_6	$H = R =$	·008		$H =$	·087		$H =$	·201		$H =$	·708
	$\kappa = \zeta =$	49°·48		$\kappa =$	257°·21		$\kappa =$	49°·32		$\kappa =$	71°·37
S_8	$H = R =$	·001	O_1	$R =$	·233	N_2	$R =$	·675	$(2SM)_2$	$R =$	·066
	$\kappa = \zeta =$	321°·34		$\zeta =$	325°·76		$\zeta =$	306°·71		$\zeta =$	240°·19
				$H =$	·209		$H =$	·689		$H =$	·068
				$\kappa =$	22°·38		$\kappa =$	44°·47		$\kappa =$	3°·11
M_1	$R =$	·044	K_1	$R =$	·454	λ_2	$R =$	...	$2N_2$	$R =$	·096
	$\zeta =$	137°·79		$\zeta =$	229°·86		$\zeta =$	...		$\zeta =$	351°·10
	$H =$	·022		$H =$	·423		$H =$	...		$H =$	·098
	$\kappa =$	184°·42		$\kappa =$	53°·14		$\kappa =$	...		$\kappa =$	309°·54
M_2	$R =$	3·666	K_2	$R =$	·550	ν_2	$R =$	·286	$(M_2N)_4$	$R =$	·250
	$\zeta =$	177°·60		$\zeta =$	265°·49		$\zeta =$	122°·11		$\zeta =$	45°·00
	$H =$	3·743		$H =$	·465		$H =$	·292		$H =$	·261
	$\kappa =$	54°·68		$\kappa =$	91°·45		$\kappa =$	17°·38		$\kappa =$	19°·84
M_3	$R =$	·029	P_1	$R =$	·158	μ_2	$R =$	·242	$(M_2K_1)_3$	$R =$	·137
	$\zeta =$	346°·31		$\zeta =$	236°·63		$\zeta =$	65°·08		$\zeta =$	316°·94
	$H =$	·030		$H =$	·158		$H =$	·252		$H =$	·131
	$\kappa =$	341°·93		$\kappa =$	46°·62		$\kappa =$	179°·24		$\kappa =$	17°·29
M_4	$R =$	·737	J_1	$R =$	·018	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·048
	$\zeta =$	275°·56		$\zeta =$	5°·68		$\zeta =$	...		$\zeta =$	29°·85
	$H =$	·768		$H =$	·017		$H =$	...		$H =$	·047
	$\kappa =$	29°·72		$\kappa =$	325°·46		$\kappa =$	...		$\kappa =$	320°·74

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·348	233°·36	·375	12°·68
„ Fortnightly „	·295	104°·37	·231	48°·22
Luni-Solar „ „	·872	278°·59	·890	41°·51
Solar-Annual „	2·762	236°·99	2·762	157°·00
„ Semi-Annual „	1·107	147°·26	1·107	347°·29

PART IV.—TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index map 10).

BY MAJOR J. M. BURN, R.E.

PERSONNEL.

Imperial Officers.

Mr. C. F. Erskine, in charge up to 14th October 1910,
Major J. M. Burn, R.E., in charge from 15th to 26th October 1910, and again from 27th November 1910.

Provincial Officers.

Mr. H. G. Shaw, in charge from 27th October to 26th November 1910.
Mr. Syed Zille Hasnain.

During the past year tidal registrations by self-registering tide-gauges were recorded at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. In addition, tide-pole readings of high and low water were taken during daylight at the ports of Bhāvnagar, Akyab and Chittagong, with the object of comparing the actual times and heights with the predictions. From 1st January 1911 the tide-pole readings at the port of Chittagong were discontinued, and in their place the readings of the diagrams recorded on a small self-registering tide-gauge erected by the port authorities have been utilised.

All the observations were made under the direction of this department and under the immediate control of the Port Officers concerned.

The reduction by harmonic analysis of the observations for 1910 of the 9 stations named above has been completed. The tide-tables for 1912 have arrived in India and have been distributed. The work of publication of the tide-tables for 40 ports for the year 1914 is in progress in England. Data for these predictions were despatched from this office in January 1911.

LIST OF TIDAL STATIONS.

The following table gives a list of the 42 ports at which tidal observations have been registered, together with the periods of observation from 1874, when tidal operations were commenced, up to the present time. The stations shown in italics are permanent; the others are minor stations which were closed on the completion of the requisite registrations.

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez . . .	Automatic .	1897	1903	7	
2	Perim . . .	Ditto .	1898	1902	5	
3	*Aden* . . .	Ditto .	1879	Still working	32	
4	Maskat . . .	Ditto .	1893	1898	5	
5	Bushire . . .	Ditto .	1892	1901	8	
6	*Karāchi* . .	Ditto .	1868 1881	1880 Still working	*13 31 } 44	* Small Tide-Gauge working.
7	Hanstal . . .	Ditto .	1874	1875	1	Tide-Tables not published.
8	Navānāi . .	Ditto .	1874	1875	1	Ditto.
9	Okhā Point . .	Ditto .	1874 Re-started 1904	1875 1906	1 1 } 2	Year 1904-05 is excluded.
10	Porbandar . .	Personal .	1893	1894	2	

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
10A	Porbandar	Automatic	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kāthiāwār).	Personal	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār).	Automatic	1900	1903	4	
12	Bhāvnagar	Ditto	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto	1878	Still working	33	
14	*Bombay (Prince's Dock).*	Ditto	1888	Still working	23	Property of Port Trust.
15	Marmagao (Goa)	Ditto	1884	1889	5	
16	Kārwār	Ditto	1878	1883	5	
17	Beypore	Ditto	1878	1884	6	
18	Cochin	Ditto	1886	1892	6	
19	Tuticorin	Ditto	1888	1893	5	
20	Minicoy	Ditto	1891	1896	5	
21	Galle	Ditto	1884	1890	6	
22	Colombo	Ditto	1884	1890	6	
23	Trincomalee	Ditto	1890	1896	6	
24	Pāmban Pass	Ditto	1878	1882	4	
25	Negapatam	Ditto	1881	1888	5	Years 1883-1884, 1885 are excluded.
26	*Madras*	Ditto	1880 Re-started 1895	1890 Still working	10 } 26 16 }	
27	Cocanāda	Ditto	1886	1891	5	
28	Vizagapatam	Ditto	1879	1885	6	
29	False Point	Ditto	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto	1881	1886	5	
31	Diamond Harbour	Ditto	1881	1886	5	
32	*Kidderpore*	Ditto	1881	Still working	30	
33	Chittagong	Ditto	1886	1891	5	
34	Akyab	Ditto	1887	1892	5	
35	Diamond Island	Ditto	1895	1899	5	
36	Bassein (Burma)	Ditto	1902	1903	2	
37	Elephant Point	Ditto	1880 Re-started 1884	1881 1888	5	Year 1880-81 is excluded.
38	*Rangoon*	Ditto	1880	Still working	31	
39	Amherst	Ditto	1880	1886	6	
40	*Moulmein*	Ditto	1880 Re-started 1909	1886 Still working	6 } 8 2 }	
41	Mergui	Ditto	1889	1894	5	
42	*Port Blair*	Ditto	1880	Still working	31	

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WORKING OF THE OBSERVATORIES.

The nine tidal observatories now working were inspected during the year by Mr. Syed Zille Hasnain.

Aden.—As mentioned in last year's report the communication hole at the bottom of the float cylinder had become too large. It was therefore removed during this year's inspection, and a new cylinder which was made by the Port Engineer was fixed in its place. The tide-gauge was found to have worked satisfactorily since the last inspection. It was thoroughly cleaned and overhauled.

Karāchi.—This observatory was found in good order. The communication hole at the bottom of the cylinder was partially blocked by barnacles. It was thoroughly cleaned and the tide-gauge was overhauled and left in working order. There have been no breaks in the tidal registrations during the year.

Apollo Bandar (Bombay).—This observatory has worked well throughout the year. There was one minor interruption in the registration of the tide-gauge.

Prince's Dock (Bombay).—There have been a few short interruptions in the registration of the tide-gauge at this observatory owing to the pencil wire breaking.

Madras.—As the sluice at the bottom of the well of this observatory through which communication between the sea and the well is regulated had not been working satisfactorily for the past two years, steps were taken during this year's inspection to have it removed and replaced by a new one. This work took some days, and the registrations of the tide-gauge were consequently stopped from the 10th to the 21st February 1911. Opportunity was also taken to have the well thoroughly cleaned and repaired. With the exception of the above break, there have been no interruptions in the tidal registrations during the year. The old entrance to the harbour which was immediately south of the observatory has now been closed, and a new entrance has been made in the north arm of the harbour.

Kidderpore.—The tide-gauge at this observatory has worked well throughout the year. There was only one interruption of a few hours in the registrations owing to the stoppage of the driving clock. The inspecting officer found that a good deal of mud had collected near the bottom of the cylinder which was likely to interfere with free communication between the sea and the cylinder. The matter having been brought to the notice of the Deputy Conservator of the Port, the necessary dredging was carried out.

Rangoon.—There have been no breaks in the registrations of the tide-gauge at this observatory during the year. The tide-gauge and the auxiliary instruments were thoroughly cleaned and put in order.

Moulmein.—The tide-gauge at this observatory has worked well during the year, except for a few minor interruptions in its registrations owing to the stoppage of the driving clock. The inspecting officer found the graduated staff inaccurately divided. It was therefore removed and a new graduated staff was prepared and fixed in place of the old one.

Port Blair.—There has been only one interruption of a few hours in the registrations of the tide-gauge at this observatory owing to the stoppage of the driving clock. During the inspection the zero of the graduated staff was found

to differ by 0·1 of a foot from the zero of the tide-gauge. The staff was removed and refixed in its proper position so that its zero is now identical with the zero of the gauge.

TIDAL DIAGRAMS AND DAILY REPORTS.

The tidal diagrams and daily reports have been submitted regularly to the office of this party by the various port officials concerned.

TIDAL CONSTANTS.

The tidal observations at the nine working stations for the year 1910 have been reduced, and the tabulated values of the tidal constants thus determined are appended. There are no arrears.

The following tables give the amplitudes (R) and the epochs (ζ) deduced from the 1910 observations at the various stations; they also give the values of H and κ which are connected with R and ζ in such a way, through the various astronomical quantities involved in the positions of the sun and moon, that if the tidal observations were consistent from year to year H and κ would come out the same from each year's reductions.

ADEN, 1910.

Short Period Tides.

A_0 = 5·836 feet.

S_1	H = R =	·095	M_6	R =	·007	Q_1	R =	·139	T_2	R =	·049
S_1	κ = ζ =	178°·73		ζ =	329°·20		ζ =	132°·69		ζ =	290°·68
S_2	H = R =	·685		H =	·007		H =	·125		H =	·049
S_2	κ = ζ =	241°·96		κ =	311°·63		κ =	45°·36		κ =	291°·94
S_4	H = R =	·002	M_8	R =	·001	L_2	R =	·017	$(MS)_4$	R =	·010
S_4	κ = ζ =	262°·88		ζ =	74°·75		ζ =	44°·53		ζ =	246°·41
S_6	H = R =	·004		H =	·001		H =	·021		H =	·010
S_6	κ = ζ =	211°·19		κ =	291°·32		κ =	219°·95		κ =	120°·55
S_8	H = R =	·001	O_1	R =	·728	N_2	R =	·417	$(2SM)_2$	R =	·007
S_8	κ = ζ =	128°·66		ζ =	343°·04		ζ =	128°·74		ζ =	300°·51
				H =	·652		H =	·425		H =	·007
				κ =	36°·60		κ =	221°·99		κ =	66°·37
M_1	R =	·076	K_1	R =	1·397	λ_2	R =	...	$2N_2$	R =	·079
	ζ =	28°·12		ζ =	210°·38		ζ =	...		ζ =	221°·29
	H =	·039		H =	1·302		H =	...		H =	·080
	κ =	73°·29		κ =	33°·77		κ =	...		κ =	173°·64
M_2	R =	1·515	K_2	R =	·226	ν_2	R =	·108	$(M_2N)_4$	R =	·008
	ζ =	351°·27		ζ =	53°·72		ζ =	300°·04		ζ =	247°·09
	H =	1·546		H =	·191		H =	·110		H =	·008
	k =	225°·41		κ =	239°·92		κ =	191°·01		κ =	214°·49
M_3	R =	·016	P_1	R =	·420	μ_2	R =	·069	$(M_2K_1)_3$	R =	·015
	ζ =	201°·94		ζ =	223°·50		ζ =	64°·76		ζ =	37°·33
	H =	·016		H =	·420		H =	·072		H =	·015
	κ =	193°·16		κ =	33°·37		κ =	173°·05		κ =	94°·87
M_4	R =	·006	J_1	R =	·081	R_2	R =	...	$(2M_2K_1)_3$	R =	·004
	ζ =	160°·91		ζ =	66°·02		ζ =	...		ζ =	54°·64
	H =	·006		H =	·073		H =	...		H =	·004
	κ =	269°·19		κ =	27°·50		κ =	...		κ =	339°·53

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·023	263°·46	·025	44°·35
„ Fortnightly „	·075	69°·57	·059	16°·59
Luni-Solar „ „ . . .	·009	336°·15	·009	102°·00
Solar-Annual „	·309	85°·65	·309	5°·78
„ Semi-Annual „	·086	281°·73	·086	122°·00

KARĀCHI, 1910.

Short Period Tides.

$A_0 = 7·233$ feet.

S_1	$H = R =$	·095	M_6	$R =$	·044	Q_1	$R =$	·143	T_2	$R =$	·087
	$\kappa = \zeta =$	188°·94		$\zeta =$	225°·61		$\zeta =$	142°·58		$\zeta =$	10°·68
S_2	$H = R =$	·973		$H =$	·047		$H =$	·128		$H =$	·087
	$\kappa = \zeta =$	322°·68		$\kappa =$	212°·52		$\kappa =$	57°·59		$\kappa =$	12°·00
S_4	$H = R =$	·011	M_8	$R =$	·005	L_2	$R =$	·033	$(MS)_4$	$R =$	·035
	$\kappa = \zeta =$	4°·12		$\zeta =$	31°·87		$\zeta =$	103°·95		$\zeta =$	83°·13
S_6	$H = R =$	·007		$H =$	·006		$H =$	·040		$H =$	·036
	$\kappa = \zeta =$	317°·29		$\kappa =$	254°·41		$\kappa =$	280°·07		$\kappa =$	318°·77
S_8	$H = R =$	·002	O_1	$R =$	·740	N_2	$R =$	·607	$(2SM)_2$	$R =$	·011
	$\kappa = \zeta =$	74°·06		$\zeta =$	352°·38		$\zeta =$	185°·40		$\zeta =$	333°·67
				$H =$	·662		$H =$	·619		$H =$	·011
				$\kappa =$	47°·50		$\kappa =$	280°·94		$\kappa =$	98°·04
M_1	$R =$	·090	K_1	$R =$	1·430	λ_2	$R =$	...	$2N_2$	$R =$	·115
	$\zeta =$	36°·56		$\zeta =$	223°·06		$\zeta =$	...		$\zeta =$	295°·35
	$H =$	·046		$H =$	1·333		$H =$	...		$H =$	·118
	$\kappa =$	82°·48		$\kappa =$	46°·39		$\kappa =$	...		$\kappa =$	250°·79
M_2	$R =$	2·536	K_2	$R =$	·315	ν_2	$R =$	·163	$(M_2N)_4$	$R =$	·019
	$\zeta =$	58°·83		$\zeta =$	134°·56		$\zeta =$	353°·75		$\zeta =$	27°·82
	$H =$	2·590		$H =$	·266		$H =$	·166		$H =$	·020
	$\kappa =$	294°·46		$\kappa =$	320°·64		$\kappa =$	246°·91		$\kappa =$	358°·99
M_3	$R =$	·035	P_1	$R =$	·409	μ_2	$R =$	·070	$(M_2K_1)_3$	$R =$	·013
	$\zeta =$	352°·30		$\zeta =$	235°·40		$\zeta =$	130°·91		$\zeta =$	51°·82
	$H =$	·036		$H =$	·409		$H =$	·073		$H =$	·013
	$\kappa =$	345°·76		$\kappa =$	45°·32		$\kappa =$	242°·19		$\kappa =$	110°·79
M_4	$R =$	·014	J_1	$R =$	·077	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·029
	$\zeta =$	208°·10		$\zeta =$	82°·64		$\zeta =$	...		$\zeta =$	64°·26
	$H =$	·015		$H =$	·069		$H =$	...		$H =$	·028
	$\kappa =$	319°·37		$\kappa =$	43°·26		$\kappa =$	...		$\kappa =$	352°·20

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·018	138°·97	·019	279°·07
„ Fortnightly „	·046	75°·51	·036	20°·91
Luni-Solar „ „	·011	356°·43	·011	120°·79
Solar-Annual „	·137	168°·26	·137	88°·33
„ Semi-Annual „	·147	329°·85	·147	170°·00

BOMBAY (APOLLO BANDAR), 1910.

Short Period Tides.

$A_0 = 10{\cdot}204$ feet.

S_1	$H = R =$	·062	M_6	$R =$	·016	Q_1	$R =$	·139	T_2	$R =$	·163
	$\kappa = \zeta =$	196°·78		$\zeta =$	26°·57		$\zeta =$	145°·18		$\zeta =$	44°·97
S_2	$H = R =$	1·555		$H =$	·017		$H =$	·125		$H =$	·163
	$\kappa = \zeta =$	2°·30		$\kappa =$	14°·66		$\kappa =$	60°·82		$\kappa =$	46°·31
S_4	$H = R =$	·014	M_8	$R =$	·009	L_2	$R =$	·016	$(MS)_4$	$R =$	·085
	$\kappa = \zeta =$	251°·31		$\zeta =$	114°·57		$\zeta =$	332°·77		$\zeta =$	146°·35
S_6	$H = R =$	·002		$H =$	·010		$H =$	·019		$H =$	·086
	$\kappa = \zeta =$	190°·31		$\kappa =$	338°·70		$\kappa =$	149°·07		$\kappa =$	22°·38
S_8	$H = R =$	·002	O_1	$R =$	·721	N_2	$R =$	·949	$(2SM)_2$	$R =$	·036
	$\kappa = \zeta =$	115°·46		$\zeta =$	352°·78		$\zeta =$	218°·37		$\zeta =$	334°·00
				$H =$	·645		$H =$	·969		$H =$	·037
				$\kappa =$	48°·31		$\kappa =$	314°·52		$\kappa =$	97°·97
M_1	$R =$	·094	K_1	$R =$	1·496	λ_2	$R =$	...	$2N_2$	$R =$	·118
	$\zeta =$	35°·39		$\zeta =$	221°·68		$\zeta =$	...		$\zeta =$	334°·56
	$H =$	·048		$H =$	1·394		$H =$	...		$H =$	·120
	$\kappa =$	81°·50		$\kappa =$	45°·00		$\kappa =$	...		$\kappa =$	290°·82
M_2	$R =$	3·853	K_2	$R =$	·481	ν_2	$R =$	·240	$(M_2N)_4$	$R =$	·017
	$\zeta =$	93°·96		$\zeta =$	171°·68		$\zeta =$	23°·08		$\zeta =$	240°·91
	$H =$	3·934		$H =$	·407		$H =$	·245		$H =$	·018
	$\kappa =$	329°·99		$\kappa =$	357°·73		$\kappa =$	276°·82		$\kappa =$	213°·09
M_3	$R =$	·074	P_1	$R =$	·404	μ_2	$R =$	·205	$(M_2K_1)_3$	$R =$	·087
	$\zeta =$	23°·12		$\zeta =$	234°·98		$\zeta =$	181°·08		$\zeta =$	148°·61
	$H =$	·076		$H =$	·404		$H =$	·214		$H =$	·083
	$\kappa =$	17°·16		$\kappa =$	44°·92		$\kappa =$	293°·14		$\kappa =$	207°·96
M_4	$R =$	·082	J_1	$R =$	·080	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·064
	$\zeta =$	187°·34		$\zeta =$	88°·64		$\zeta =$	...		$\zeta =$	135°·07
	$H =$	·085		$H =$	·072		$H =$	...		$H =$	·062
	$\kappa =$	299°·41		$\kappa =$	49°·03		$\kappa =$	...		$\kappa =$	63°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·009	334°·26	·010	114°·14
„ Fortnightly „	·043	73°·05	·034	18°·03
Luni-Solar „ „	·024	251°·94	·025	15°·91
Solar-Annual „	·057	41°·04	·057	324°·10
„ Semi-Annual „	·135	357°·13	·135	197°·25

BOMBAY (PRINCE'S DOCK), 1910.

Short Period Tides.

$A_0 = 8{\cdot}201$ feet.

S_1	$H = R =$	·085	M_6	$R =$	·012	Q_1	$R =$	·143	T_2	$R =$	·167
	$\kappa = \zeta =$	190°·85		$\zeta =$	219°·14		$\zeta =$	145°·74		$\zeta =$	45°·00
S_2	$H = R =$	1·594		$H =$	·013		$H =$	·128		$H =$	·167
	$\kappa = \zeta =$	5°·58		$\kappa =$	207°·24		$\kappa =$	61°·38		$\kappa =$	46°·34
S_4	$H = R =$	·020	M_8	$R =$	·002	L_2	$R =$	·023	$(MS)_4$	$R =$	·117
	$\kappa = \zeta =$	218°·21		$\zeta =$	198°·44		$\zeta =$	10°·73		$\zeta =$	168°·09
S_6	$H = R =$	·004		$H =$	·003		$H =$	·028		$H =$	·120
	$\kappa = \zeta =$	181°·51		$\kappa =$	62°·56		$\kappa =$	187°·02		$\kappa =$	44°·12
S_8	$H = R =$	·002	O_1	$R =$	·735	N_2	$R =$	·968	$(2SM)_2$	$R =$	·041
	$\kappa = \zeta =$	184°·76		$\zeta =$	353°·23		$\zeta =$	221°·49		$\zeta =$	352°·38
				$H =$	·657		$H =$	·989		$H =$	·041
				$\kappa =$	48°·76		$\kappa =$	317°·63		$\kappa =$	116°·35
M_1	$R =$	·101	K_1	$R =$	1·504	λ_2	$R =$	...	$2N_2$	$R =$	·109
	$\zeta =$	35°·00		$\zeta =$	222°·38		$\zeta =$	...		$\zeta =$	338°·12
	$H =$	·052		$H =$	1·402		$H =$	...		$H =$	·111
	$\kappa =$	81°·11		$\kappa =$	45°·70		$\kappa =$	...		$\kappa =$	294°·38
M_2	$R =$	3·958	K_2	$R =$	·497	ν_2	$R =$	·234	$(M_2N)_4$	$R =$	·007
	$\zeta =$	96°·41		$\zeta =$	175°·95		$\zeta =$	23°·94		$\zeta =$	124°·38
	$H =$	4·041		$H =$	·421		$H =$	·239		$H =$	·008
	$\kappa =$	332°·44		$\kappa =$	2°·00		$\kappa =$	276°·67		$\kappa =$	96°·56
M_3	$R =$	·077	P_1	$R =$	·409	μ_2	$R =$	·211	$(M_2K_1)_3$	$R =$	·091
	$\zeta =$	28°·68		$\zeta =$	235°·76		$\zeta =$	188°·58		$\zeta =$	136°·10
	$H =$	·079		$H =$	·409		$H =$	·220		$H =$	·086
	$\kappa =$	22°·68		$\kappa =$	45°·70		$\kappa =$	300°·65		$\kappa =$	195°·45
M_4	$R =$	·087	J_1	$R =$	·082	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·081
	$\zeta =$	225°·10		$\zeta =$	87°·97		$\zeta =$	...		$\zeta =$	150°·44
	$H =$	·091		$H =$	·074		$H =$	...		$H =$	·078
	$\kappa =$	337°·16		$\kappa =$	48°·36		$\kappa =$	...		$\kappa =$	79°·18

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·016	265°·64	·017	45°·53
„ Fortnightly „	·051	77°·07	·040	22°·04
Luni-Solar „ „	·041	247°·61	042	11°·57
Solar-Annual „	·053	50°·11	·053	330°·17
„ Semi-Annual „	·146	353°·48	·146	193°·60

MADRAS, 1910.

Short Period Tides.

$A_0 = 2{\cdot}412$ feet.

S_1	$H = R =$	·030	M_6	$R =$	·003	Q_1	$R =$	·002	T_2	$R =$	·028
	$\kappa = \zeta =$	94°·90		$\zeta =$	151°·70		$\zeta =$	113°·20		$\zeta =$	319°·15
S_2	$H = R =$	·461		$H =$	·004		$H =$	·001		$H =$	·028
	$\kappa = \zeta =$	269°·76		$\kappa =$	141°·30		$\kappa =$	29°·63		$\kappa =$	320°·51
S_4	$H = R =$	·001	M_8	$R =$	·001	L_2	$R =$	·017	$(MS)_4$	$R =$	·004
	$\kappa = \zeta =$	345°·96		$\zeta =$	257°·47		$\zeta =$	93°·24		$\zeta =$	79°·29
S_6	$H = R =$	·002		$H =$	·001		$H =$	·056		$H =$	·004
	$\kappa = \zeta =$	81°·03		$\kappa =$	123°·61		$\kappa =$	269°·76		$\kappa =$	315°·82
S_8	$H = R =$	·001	O_1	$R =$	·106	N_2	$R =$	·233	$(2SM)_2$	$R =$	·020
	$\kappa = \zeta =$	23°·96		$\zeta =$	268°·37		$\zeta =$	140°·52		$\zeta =$	106°·47
				$H =$	·095		$H =$	·238		$H =$	·020
				$\kappa =$	324°·42		$\kappa =$	237°·44		$\kappa =$	229°·94
M_1	$R =$	·007	K_1	$R =$	·324	λ_2	$R =$	...	$2N_2$	$R =$	·043
	$\zeta =$	354°·45		$\zeta =$	152°·75		$\zeta =$	...		$\zeta =$	253°·60
	$H =$	·004		$H =$	·302		$H =$	...		$H =$	·044
	$\kappa =$	40°·81		$\kappa =$	336°·05		$\kappa =$	...		$\kappa =$	210°·90
M_2	$R =$	1·053	K_2	$R =$	·148	ν_2	$R =$	·061	$(M_2N)_4$	$R =$	·003
	$\zeta =$	4°·31		$\zeta =$	84°·91		$\zeta =$	312°·26		$\zeta =$	151°·82
	$H =$	1·075		$H =$	·126		$H =$	·063		$H =$	·004
	$\kappa =$	240°·85		$\kappa =$	270°·92		$\kappa =$	206°·73		$\kappa =$	125°·28
M_3	$R =$	·003	P_1	$R =$	·096	μ_2	$R =$	·010	$(M_2K_1)_3$	$R =$	·010
	$\zeta =$	52°·70		$\zeta =$	168°·16		$\zeta =$	54°·89		$\zeta =$	86°·39
	$H =$	·003		$H =$	·096		$H =$	·041		$H =$	·009
	$\kappa =$	47°·50		$\kappa =$	338°·12		$\kappa =$	167°·96		$\kappa =$	146°·22
M_4	$R =$	·003	J_1	$R =$	·013	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·002
	$\zeta =$	94°·40		$\zeta =$	215°·13		$\zeta =$	...		$\zeta =$	28°·07
	$H =$	·003		$H =$	·012		$H =$	...		$H =$	·002
	$\kappa =$	207°·47		$\kappa =$	175°·23		$\kappa =$	...		$\kappa =$	317°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·058	218°·58	·063	358°·19
„ Fortnightly „	·055	48°·04	·043	352°·48
Luni-Solar „ „	·024	21°·15	·025	144°·61
Solar-Annual „	·504	278°·46	·504	198°·49
„ Semi-Annual „	·235	267°·78	·235	107°·85

KIDDERPORE, 1910.

Short Period Tides.

$A_0 = 10{\cdot}895$ feet.

S_1	H = R =	·090	M_6	R =	·165	Q_1	R =	·016	T_2	R =	·203
	κ = ζ =	192°·21		ζ =	321°·19		ζ =	100°·01		ζ =	156°·39
S_2	H = R =	1·553		H =	·175		H =	·014		H =	·203
	κ = ζ =	95°·61		κ =	312°·43		κ =	17°·31		κ =	157°·77
S_4	H = R =	·107	M_8	R =	·080	L_2	R =	·168	$(MS)_4$	R =	·693
	κ = ζ =	106°·65		ζ =	28°·89		ζ =	232°·54		ζ =	194°·29
S_6	H = R =	·008		H =	·087		H =	·201		H =	·708
	κ = ζ =	49°·48		κ =	257°·21		κ =	49°·32		κ =	71°·37
S_8	H = R =	·001	O_1	R =	·233	N_2	R =	·675	$(2SM)_2$	R =	·066
	κ = ζ =	321°·34		ζ =	325°·76		ζ =	306°·71		ζ =	240°·19
				H =	·209		H =	·689		H =	·068
				κ =	22°·38		κ =	44°·47		κ =	3°·11
M_1	R =	·044	K_1	R =	·454	λ_2	R =	...	$2N_2$	R =	·096
	ζ =	137°·79		ζ =	229°·86		ζ =	...		ζ =	351°·10
	H =	·022		H =	·423		H =	...		H =	·098
	κ =	184°·42		κ =	53°·14		κ =	...		κ =	309°·54
M_2	R =	3·666	K_2	R =	·550	ν_2	R =	·286	$(M_2N)_4$	R =	·250
	ζ =	177°·60		ζ =	265°·49		ζ =	122°·11		ζ =	45°·00
	H =	3·743		H =	·465		H =	·292		H =	·261
	κ =	54°·68		κ =	91°·45		κ =	17°·38		κ =	19°·84
M_3	R =	·029	P_1	R =	·158	μ_2	R =	·242	$(M_2K_1)_3$	R =	·137
	ζ =	346°·31		ζ =	236°·63		ζ =	65°·08		ζ =	316°·94
	H =	·030		H =	·158		H =	·252		H =	·131
	κ =	341°·93		κ =	46°·62		κ =	179°·24		κ =	17°·29
M_4	R =	·737	J_1	R =	·018	R_2	R =	...	$(2M_2K_1)_3$	R =	·048
	ζ =	275°·56		ζ =	5°·68		ζ =	...		ζ =	29°·85
	H =	·768		H =	·017		H =	...		H =	·047
	κ =	29°·72		κ =	325°·46		κ =	...		κ =	320°·74

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·348	233°·36	·375	12°·68
„ Fortnightly „	·295	104°·37	·231	48°·22
Luni-Solar „ „	·872	278°·59	·890	41°·51
Solar-Annual „	2·762	236°·99	2·762	157°·00
„ Semi-Annual „	1·107	147°·26	1·107	347°·29

I

PART IV.—TIDAL OPERATIONS.

No. 16 PARTY.

(*Vide* Index map 10).

BY MAJOR J. M. BURN, R.E.

PERSONNEL.

Imperial Officers.

Mr. C. F. Erskine, in charge up to 14th October 1910,

Major J. M. Burn, R.E., in charge from 15th to 26th October 1910, and again from 27th November 1910.

Provincial Officers.

Mr. H. G. Shaw, in charge from 27th October to 26th November 1910.

Mr. Syed Zille Hasnain.

During the past year tidal registrations by self-registering tide-gauges were recorded at the ports of Aden, Karāchi, Apollo Bandar (Bombay), Prince's Dock (Bombay), Madras, Kidderpore, Rangoon, Moulmein and Port Blair. In addition, tide-pole readings of high and low water were taken during daylight at the ports of Bhāvnagar, Akyab and Chittagong, with the object of comparing the actual times and heights with the predictions. From 1st January 1911 the tide-pole readings at the port of Chittagong were discontinued, and in their place the readings of the diagrams recorded on a small self-registering tide-gauge erected by the port authorities have been utilised.

All the observations were made under the direction of this department and under the immediate control of the Port Officers concerned.

The reduction by harmonic analysis of the observations for 1910 of the 9 stations named above has been completed. The tide-tables for 1912 have arrived in India and have been distributed. The work of publication of the tide-tables for 40 ports for the year 1914 is in progress in England. Data for these predictions were despatched from this office in January 1911.

LIST OF TIDAL STATIONS.

The following table gives a list of the 42 ports at which tidal observations have been registered, together with the periods of observation from 1874, when tidal operations were commenced, up to the present time. The stations shown in italics are permanent; the others are minor stations which were closed on the completion of the requisite registrations.

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
1	Suez	Automatic	1897	1903	7	
2	Perim	Ditto	1898	1902	5	
3	*Aden*	Ditto	1879	Still working	32	
4	Maskat	Ditto	1893	1898	5	
5	Bushire	Ditto	1892	1901	8	
6	*Karāchi*	Ditto	1868 1881	1880 Still working	*13 } 44 31 }	* Small Tide-Gauge working.
7	Hanstal	Ditto	1874	1875	1	Tide-Tables not published.
8	Navānār	Ditto	1874	1875	1	Ditto.
9	Okhā Point	Ditto	1874 Re-started 1904	1875 1906	1 } 2 1 }	Year 1904-05 is excluded.
10	Porbandar	Personal	1893	1894	2	

Serial No.	Stations.	Automatic or personal observations.	Date of commencement of observations.	Date of closing of observations.	Number of years of observations.	REMARKS.
10A	Porbandar . .	Automatic .	1898	1902	2	Years 1898, 1899 and 1902 are excluded.
11	Port Albert Victor (Kāthiāwār).	Personal .	1881	1882	1	
11A	Port Albert Victor (Kāthiāwār).	Automatic .	1900	1903	4	
12	Bhāvnagar . .	Ditto .	1889	1894	5	
13	*Bombay (Apollo Bandar).*	Ditto .	1878	Still working	33	
14	*Bombay (Prince's Dock).*	Ditto .	1888	Still working	23	Property of Port Trust.
15	Marmagao (Goa) .	Ditto	1884	1889	5	
16	Kārwār . . .	Ditto .	1878	1883	5	
17	Beypore . .	Ditto .	1878	1884	6	
18	Cochin . . .	Ditto .	1886	1892	6	
19	Tuticorin . . .	Ditto .	1888	1893	5	
20	Minicoy . . .	Ditto .	1891	1896	5	
21	Galle . . .	Ditto .	1884	1890	6	
22	Colombo . .	Ditto	1884	1890	6	
23	Trincomalee . .	Ditto .	1890	1896	6	
24	Pāmban Pass . .	Ditto .	1878	1882	4	
25	Negapatam . .	Ditto .	1881	1888	5	Years 1883-1884, 1885 are excluded.
26	*Madras* . .	Ditto .	1880 Re-started 1895	1890 Still working	10 } 26 16 }	
27	Cocanāda . .	Ditto .	1886	1891	5	
28	Vizagapatam . .	Ditto .	1879	1885	6	
29	False Point . .	Ditto .	1881	1885	4	
30	Dublat (Sāgar Island)	Ditto .	1881	1886	5	
31	Diamond Harbour .	Ditto .	1881	1886	5	
32	*Kidderpore* . .	Ditto .	1881	Still working	30	
33	Chittagong . .	Ditto .	1886	1891	5	
34	Akyab . . .	Ditto .	1887	1892	5	
35	Diamond Island .	Ditto .	1895	1899	5	
36	Bassein (Burma) .	Ditto	1902	1903	2	
37	Elephant Point .	Ditto .	1880 Re-started 1884	1881 1888	5	Year 1880-81 is excluded.
38	*Rangoon* . .	Ditto .	1880	Still working	31	
39	Amherst . .	Ditto .	1880	1886	6	
40	*Moulmein* . .	Ditto .	1880 Re-started 1909	1886 Still working	6 } 8 2 }	
41	Mergui . . .	Ditto .	1889	1894	5	
42	*Port Blair* . . .	Ditto .	1880	Still working	31	

WORKING OF THE OBSERVATORIES.

The nine tidal observatories now working were inspected during the year by Mr. Syed Zille Hasnain.

Aden.—As mentioned in last year's report the communication hole at the bottom of the float cylinder had become too large. It was therefore removed during this year's inspection, and a new cylinder which was made by the Port Engineer was fixed in its place. The tide-gauge was found to have worked satisfactorily since the last inspection. It was thoroughly cleaned and overhauled.

Karāchi.—This observatory was found in good order. The communication hole at the bottom of the cylinder was partially blocked by barnacles. It was thoroughly cleaned and the tide-gauge was overhauled and left in working order. There have been no breaks in the tidal registrations during the year.

Apollo Bandar (Bombay).—This observatory has worked well throughout the year. There was one minor interruption in the registration of the tide-gauge.

Prince's Dock (Bombay).—There have been a few short interruptions in the registration of the tide-gauge at this observatory owing to the pencil wire breaking.

Madras.—As the sluice at the bottom of the well of this observatory through which communication between the sea and the well is regulated had not been working satisfactorily for the past two years, steps were taken during this year's inspection to have it removed and replaced by a new one. This work took some days, and the registrations of the tide-gauge were consequently stopped from the 10th to the 21st February 1911. Opportunity was also taken to have the well thoroughly cleaned and repaired. With the exception of the above break, there have been no interruptions in the tidal registrations during the year. The old entrance to the harbour which was immediately south of the observatory has now been closed, and a new entrance has been made in the north arm of the harbour.

Kidderpore.—The tide-gauge at this observatory has worked well throughout the year. There was only one interruption of a few hours in the registrations owing to the stoppage of the driving clock. The inspecting officer found that a good deal of mud had collected near the bottom of the cylinder which was likely to interfere with free communication between the sea and the cylinder. The matter having been brought to the notice of the Deputy Conservator of the Port, the necessary dredging was carried out.

Rangoon.—There have been no breaks in the registrations of the tide-gauge at this observatory during the year. The tide-gauge and the auxiliary instruments were thoroughly cleaned and put in order.

Moulmein.—The tide-gauge at this observatory has worked well during the year, except for a few minor interruptions in its registrations owing to the stoppage of the driving clock. The inspecting officer found the graduated staff inaccurately divided. It was therefore removed and a new graduated staff was prepared and fixed in place of the old one.

Port Blair.—There has been only one interruption of a few hours in the registrations of the tide-gauge at this observatory owing to the stoppage of the driving clock. During the inspection the zero of the graduated staff was found

to differ by 0·1 of a foot from the zero of the tide-gauge. The staff was removed and refixed in its proper position so that its zero is now identical with the zero of the gauge.

TIDAL DIAGRAMS AND DAILY REPORTS.

The tidal diagrams and daily reports have been submitted regularly to the office of this party by the various port officials concerned.

TIDAL CONSTANTS.

The tidal observations at the nine working stations for the year 1910 have been reduced, and the tabulated values of the tidal constants thus determined are appended. There are no arrears.

The following tables give the amplitudes (R) and the epochs (ζ) deduced from the 1910 observations at the various stations; they also give the values of H and κ which are connected with R and ζ in such a way, through the various astronomical quantities involved in the positions of the sun and moon, that if the tidal observations were consistent from year to year H and κ would come out the same from each year's reductions.

ADEN, 1910.

Short Period Tides.

$A_0 = 5{\cdot}836$ feet.

S_1 H = R =	·095	M_6 R =	·007	Q_1 R =	·139	T_2 R =	·049
κ = ζ =	178°·73	ζ =	329°·20	ζ =	132°·69	ζ =	290°·68
S_2 H = R =	·685	H =	·007	H =	·125	H =	·049
κ = ζ =	241°·96	κ =	311°·63	κ =	45°·36	κ =	291°·94
S_4 H = R =	·002	M_8 R =	·001	L_2 R =	·017	$(MS)_4$ R =	·010
κ = ζ =	262°·88	ζ =	74°·75	ζ =	44°·53	ζ =	246°·41
S_6 H = R =	·004	H =	·001	H =	·021	H =	·010
κ = ζ =	211°·19	κ =	291°·32	κ =	219°·95	κ =	120°·55
S_8 H = R =	·001	O_1 R =	·728	N_2 R =	·417	$(2SM)_2$ R =	·007
κ = ζ =	128°·66	ζ =	343°·04	ζ =	128°·74	ζ =	300°·51
		H =	·652	H =	·425	H =	·007
		κ =	36°·60	κ =	221°·99	κ =	66°·37
M_1 R =	·076	K_1 R =	1·397	λ_2 R =	...	$2N_2$ R =	·079
ζ =	28°·12	ζ =	210°·38	ζ =	...	ζ =	221°·29
H =	·039	H =	1·302	H =	...	H =	·080
κ =	73°·29	κ =	33°·77	κ =	...	κ =	173°·64
M_2 R =	1·515	K_2 R =	·226	ν_2 R =	·108	$(M_2N)_4$ R =	·008
ζ =	351°·27	ζ =	53°·72	ζ =	300°·04	ζ =	247°·09
H =	1·546	H =	·191	H =	·110	H =	·008
k =	225°·41	κ =	239°·92	κ =	191°·01	κ =	214°·49
M_3 R =	·016	P_1 R =	·420	μ_2 R =	·069	$(M_2K_1)_3$ R =	·015
ζ =	201°·94	ζ =	223°·50	ζ =	64°·76	ζ =	37°·33
H =	·016	H =	·420	H =	·072	H =	·015
κ =	193°·16	κ =	33°·37	κ =	173°·05	κ =	94°·87
M_4 R =	·006	J_1 R =	·081	R_2 R =	...	$(2M_2K_1)_3$ R =	·004
ζ =	160°·91	ζ =	66°·02	ζ =	...	ζ =	54°·64
H =	·006	H =	·073	H =	...	H =	·004
κ =	269°·19	κ =	27°·50	κ =	...	κ =	339°·53

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·023	263°·46	·025	44°·35
„ Fortnightly „	·075	69°·57	·059	16°·59
Luni-Solar „ „ . .	·009	336°·15	·009	102°·00
Solar-Annual „	·309	85°·65	·309	5°·78
„ Semi-Annual „	·086	281°·73	·086	122°·00

KARĀCHI, 1910.

Short Period Tides.

$A_0 = 7·233$ feet.

S_1	$H = R =$	·095
	$\kappa = \zeta =$	188°·94
S_2	$H = R =$	·973
	$\kappa = \zeta =$	322°·68
S_4	$H = R =$	·011
	$\kappa = \zeta =$	4°·12
S_6	$H = R =$	·007
	$\kappa = \zeta =$	317°·29
S_8	$H = R =$	·002
	$\kappa = \zeta =$	74°·06
M_1	$R =$	·090
	$\zeta =$	36°·56
	$H =$	·046
	$\kappa =$	82°·48
M_2	$R =$	2·536
	$\zeta =$	58°·83
	$H =$	2·590
	$\kappa =$	294°·46
M_3	$R =$	·035
	$\zeta =$	352°·30
	$H =$	·036
	$\kappa =$	345°·76
M_4	$R =$	·014
	$\zeta =$	208°·10
	$H =$	·015
	$\kappa =$	319°·37
M_6	$R =$	·044
	$\zeta =$	225°·61
	$H =$	·047
	$\kappa =$	212°·52
M_8	$R =$	·005
	$\zeta =$	31°·87
	$H =$	·006
	$\kappa =$	254°·41
O_1	$R =$	·740
	$\zeta =$	352°·38
	$H =$	·662
	$\kappa =$	47°·50
K_1	$R =$	1·430
	$\zeta =$	223°·06
	$H =$	1·333
	$\kappa =$	46°·39
K_2	$R =$	·315
	$\zeta =$	134°·56
	$H =$	·266
	$\kappa =$	320°·64
P_1	$R =$	·409
	$\zeta =$	235°·40
	$H =$	·409
	$\kappa =$	45°·32
J_1	$R =$	·077
	$\zeta =$	82°·64
	$H =$	·069
	$\kappa =$	43°·26
Q_1	$R =$	·143
	$\zeta =$	142°·58
	$H =$	·128
	$\kappa =$	57°·59
L_2	$R =$	·033
	$\zeta =$	103°·95
	$H =$	·040
	$\kappa =$	280°·07
N_2	$R =$	·607
	$\zeta =$	185°·40
	$H =$	·619
	$\kappa =$	280°·94
λ_2	$R =$	...
	$\zeta =$	...
	$H =$	...
	$\kappa =$	...
ν_2	$R =$	·163
	$\zeta =$	353°·75
	$H =$	·166
	$\kappa =$	246°·91
μ_2	$R =$	·070
	$\zeta =$	130°·91
	$H =$	·073
	$\kappa =$	242°·19
R_2	$R =$	...
	$\zeta =$	...
	$H =$	...
	$\kappa =$	...
T_2	$R =$	·087
	$\zeta =$	10°·68
	$H =$	·087
	$\kappa =$	12°·00
$(MS)_4$	$R =$	·035
	$\zeta =$	83°·13
	$H =$	·036
	$\kappa =$	318°·77
$(2SM)_2$	$R =$	·011
	$\zeta =$	333°·67
	$H =$	·011
	$\kappa =$	98°·04
$2N_2$	$R =$	·115
	$\zeta =$	295°·35
	$H =$	·118
	$\kappa =$	250°·79
$(M_2N)_4$	$R =$	·019
	$\zeta =$	27°·82
	$H =$	·020
	$\kappa =$	358°·99
$(M_2K_1)_3$	$R =$	·013
	$\zeta =$	51°·82
	$H =$	·013
	$\kappa =$	110°·79
$(2M_2K_1)_2$	$R =$	·029
	$\zeta =$	64°·26
	$H =$	·028
	$\kappa =$	352°·20

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·018	138°·97	·019	279°·07
,, **Fortnightly** ,, ...	·046	75°·51	·036	20°·91
Luni-Solar ,, ,, ...	·011	356°·43	·011	120°·79
Solar-Annual ,, ...	·137	168°·26	·137	88°·33
,, **Semi-Annual** ,, ...	·147	329°·85	·147	170°·00

BOMBAY (APOLLO BANDAR), 1910.

Short Period Tides.

A_0=10 204 feet.

S_1	H = R =	·062	M_6	R =	·016	Q_1	R =	·139	T_2	R =	·163
	κ = ζ =	196°·78		ζ =	26°·57		ζ =	145°·18		ζ =	44°·97
S_2	H = R =	1·555		H =	·017		H =	·125		H =	·163
	κ = ζ =	2°·30		κ =	14°·66		κ =	60°·82		κ =	46°·31
S_4	H = R =	·014	M_8	R =	·009	L_2	R =	·016	$(MS)_4$	R =	·085
	κ = ζ =	251°·31		ζ =	114°·57		ζ =	332°·77		ζ =	146°·35
S_6	H = R =	·002		H =	·010		H =	·019		H =	·086
	κ = ζ =	190°·31		κ =	338°·70		κ =	149°·07		κ =	22°·38
S_8	H = R =	·002	O_1	R =	·721	N_2	R =	·949	$(2SM)_2$	R =	·036
	κ = ζ =	115°·46		ζ =	352°·78		ζ =	218°·37		ζ =	334°·00
				H =	·645		H =	·969		H =	·037
				κ =	48°·31		κ =	314°·52		κ =	97°·97
M_1	R =	·094	K_1	R =	1·496	λ_2	R =	...	$2N_2$	R =	·118
	ζ =	35°·39		ζ =	221°·68		ζ =	...		ζ =	334°·56
	H =	·048		H =	1·394		H =	...		H =	·120
	κ =	81°·50		κ =	45°·00		κ =	...		κ =	290°·82
M_2	R =	3·853	K_2	R =	·481	ν_2	R =	·240	$(M_2N)_4$	R =	·017
	ζ =	93°·96		ζ =	171°·68		ζ =	23°·08		ζ =	240°·91
	H =	3·934		H =	·407		H =	·245		H =	·018
	κ =	329°·99		κ =	357°·73		κ =	276°·82		κ =	213°·09
M_3	R =	·074	P_1	R =	·404	μ_2	R =	·205	$(M_2K_1)_3$	R =	·087
	ζ =	23°·12		ζ =	234°·98		ζ =	181°·08		ζ =	148°·61
	H =	·076		H =	·404		H =	·214		H =	·083
	κ =	17°·16		κ =	44°·92		κ =	293°·14		κ =	207°·96
M_4	R =	·082	J_1	R =	·080	R_2	R =	...	$(2M_2K_1)_3$	R =	·064
	ζ =	187°·34		ζ =	88°·64		ζ =	...		ζ =	135°·07
	H =	·085		H =	·072		H =	...		H =	·062
	κ =	299°·41		κ =	49°·03		κ =	...		κ =	63°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·009	334°·26	·010	114°·14
„ Fortnightly „	·043	73°·05	·034	18°·03
Luni-Solar „ „	·024	251°·94	·025	15°·91
Solar-Annual „	·057	41°·04	·057	324°·10
„ Semi-Annual „	·135	357°·13	·135	197°·25

BOMBAY (PRINCE'S DOCK), 1910.

Short Period Tides.

A_0 = 8·201 feet.

S_1 H = R =	·085	M_6 R =	·012	Q_1 R =	·143	T_2 R =	·167
S_1 $\kappa = \zeta$ =	190°·85	M_6 ζ =	219°·14	Q_1 ζ =	145°·74	T_2 ζ =	45°·00
S_2 H = R =	1·594	M_6 H =	·013	Q_1 H =	·128	T_2 H =	·167
S_2 $\kappa = \zeta$ =	5°·58	M_6 κ =	207°·24	Q_1 κ =	61°·38	T_2 κ =	46°·34
S_4 H = R =	·020	M_8 R =	·002	L_2 R =	·023	$(MS)_4$ R =	·117
S_4 $\kappa = \zeta$ =	218°·21	M_8 ζ =	198°·44	L_2 ζ =	10°·73	$(MS)_4$ ζ =	168°·09
S_6 H = R =	·004	M_8 H =	·003	L_2 H =	·028	$(MS)_4$ H =	·120
S_6 $\kappa = \zeta$ =	181°·51	M_8 κ =	62°·56	L_2 κ =	187°·02	$(MS)_4$ κ =	44°·12
S_8 H = R =	·002	O_1 R =	·735	N_2 R =	·968	$(2SM)_2$ R =	·041
S_8 $\kappa = \zeta$ =	184°·76	O_1 ζ =	353°·23	N_2 ζ =	221°·49	$(2SM)_2$ ζ =	352°·38
		O_1 H =	·657	N_2 H =	·989	$(2SM)_2$ H =	·041
		O_1 κ =	48°·76	N_2 κ =	317°·63	$(2SM)_2$ κ =	116°·35
M_1 R =	·101	K_1 R =	1·504	λ_2 R =	...	$2N_2$ R =	·109
M_1 ζ =	85°·00	K_1 ζ =	222°·38	λ_2 ζ =	...	$2N_2$ ζ =	338°·12
M_1 H =	·052	K_1 H =	1·402	λ_2 H =	...	$2N_2$ H =	·111
M_1 κ =	81°·11	K_1 κ =	45°·70	λ_2 κ =	...	$2N_2$ κ =	204°·38
M_2 R =	3·958	K_2 R =	·497	ν_2 R =	·234	$(M_2N)_4$ R =	·007
M_2 ζ =	96°·41	K_2 ζ =	175°·95	ν_2 ζ =	23°·94	$(M_2N)_4$ ζ =	124°·38
M_2 H =	4·041	K_2 H =	·421	ν_2 H =	·239	$(M_2N)_4$ H =	·008
M_2 κ =	332°·44	K_2 κ =	2°·00	ν_2 κ =	276°·67	$(M_2N)_4$ κ =	96°·56
M_3 R =	·077	P_1 R =	·409	μ_2 R =	·211	$(M_2K_1)_3$ R =	·091
M_3 ζ =	28°·68	P_1 ζ =	235°·76	μ_2 ζ =	188°·58	$(M_2K_1)_3$ ζ =	136°·10
M_3 H =	·079	P_1 H =	·409	μ_2 H =	·220	$(M_2K_1)_3$ H =	·086
M_3 κ =	22°·68	P_1 κ =	45°·70	μ_2 κ =	300°·65	$(M_2K_1)_3$ κ =	195°·45
M_4 R =	·087	J_1 R =	·082	R_2 R =	...	$(2M_2K_1)_3$ R =	·081
M_4 ζ =	225°·10	J_1 ζ =	87°·97	R_2 ζ =	...	$(2M_2K_1)_3$ ζ =	150°·44
M_4 H =	·091	J_1 H =	·074	R_2 H =	...	$(2M_2K_1)_3$ H =	·078
M_4 κ =	337°·16	J_1 κ =	48°·36	R_2 κ =	...	$(2M_2K_1)_3$ κ =	79°·18

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·016	265°·64	·017	45°·53
„ Fortnightly „	·051	77°·07	·040	22°·04
Luni-Solar „ „	·041	247°·61	·042	11°·57
Solar-Annual „	·053	50°·11	·053	330°·17
„ Semi-Annual „	·146	353°·48	·146	193°·60

MADRAS, 1910.

Short Period Tides.

A_0 = 2·412 feet.

Tide	R	ζ	H	κ
S_1	H = R = ·030	κ = ζ = 94°·90		
S_2	H = R = ·461	κ = ζ = 269°·76		
S_4	H = R = ·001	κ = ζ = 345°·96		
S_6	H = R = ·002	κ = ζ = 81°·03		
S_8	H = R = ·001	κ = ζ = 23°·96		
M_1	·007	354°·45	·004	40°·81
M_2	1·053	4°·31	1·075	240°·85
M_3	·003	52°·70	·003	47°·50
M_4	·003	94°·40	·003	207°·47
M_6	·003	151°·70	·004	141°·30
M_8	·001	257°·47	·001	123°·61
O_1	·106	268°·37	·095	324°·42
K_1	·324	152°·75	·302	336°·05
K_2	·148	84°·91	·126	270°·92
P_1	·096	168°·16	·096	338°·12
J_1	·013	215°·13	·012	175°·23
Q_1	·002	113°·20	·001	29°·63
L_2	·017	93°·24	·056	269°·76
N_2	·233	140°·52	·238	237°·44
λ_2	...	...	...	...
ν_2	·061	312°·26	·063	206°·73
μ_2	·040	54°·89	·041	167°·96
R_2	...	...	...	...
T_2	·028	319°·15	·028	320°·51
$(MS)_4$	·004	79°·29	·004	315°·82
$(2SM)_2$	·020	106°·47	·020	229°·94
$2N_2$	·043	253°·60	·044	210°·90
$(M_2N)_4$	·003	151°·82	·004	125°·28
$(M_2K_1)_3$	·010	86°·39	·009	146°·22
$(2M_2K_1)_3$	·002	28°·07	·002	317°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·058	218°·58	·063	358°·19
" Fortnightly " . . .	·055	48°·04	·043	352°·48
Luni-Solar " " . . .	·024	21°·15	·025	144°·61
Solar-Annual " . . .	·504	278°·46	·504	198°·49
" Semi-Annual " . . .	·235	267°·78	·235	107°·85

KIDDERPORE, 1910.

Short Period Tides.

$A_0 = 10{\cdot}895$ feet.

S_1	$H = R =$	·090	M_6	$R =$	·165	Q_1	$R =$	·016	T_2	$R =$	·203
	$\kappa = \zeta =$	192°·21		$\zeta =$	321°·19		$\zeta =$	100°·01		$\zeta =$	156°·39
S_2	$H = R =$	1·553		$H =$	·175		$H =$	·014		$H =$	·203
	$\kappa = \zeta =$	95°·61		$\kappa =$	312°·43		$\kappa =$	17°·31		$\kappa =$	157°·77
S_4	$H = R =$	·107	M_8	$R =$	·080	L_2	$R =$	·168	$(MS)_4$	$R =$	·693
	$\kappa = \zeta =$	106°·65		$\zeta =$	28°·89		$\zeta =$	232°·54		$\zeta =$	194°·29
S_6	$H = R =$	·008		$H =$	·087		$H =$	·201		$H =$	·708
	$\kappa = \zeta =$	49°·48		$\kappa =$	257°·21		$\kappa =$	49°·32		$\kappa =$	71°·37
S_8	$H = R =$	·001	O_1	$R =$	·233	N_2	$R =$	·675	$(2SM)_2$	$R =$	·066
	$\kappa = \zeta =$	321°·34		$\zeta =$	325°·76		$\zeta =$	306°·71		$\zeta =$	240°·19
				$H =$	·209		$H =$	·689		$H =$	·068
				$\kappa =$	22°·38		$\kappa =$	44°·47		$\kappa =$	3°·11
M_1	$R =$	·044	K_1	$R =$	·454	λ_2	$R =$	...	$2N_2$	$R =$	·096
	$\zeta =$	137°·79		$\zeta =$	229°·86		$\zeta =$	...		$\zeta =$	351°·10
	$H =$	·022		$H =$	·423		$H =$	...		$H =$	·098
	$\kappa =$	184°·42		$\kappa =$	53°·14		$\kappa =$	...		$\kappa =$	309°·54
M_2	$R =$	3·666	K_2	$R =$	·550	ν_2	$R =$	·286	$(M_2N)_4$	$R =$	·250
	$\zeta =$	177°·60		$\zeta =$	265°·49		$\zeta =$	122°·11		$\zeta =$	45°·00
	$H =$	3·743		$H =$	·465		$H =$	·292		$H =$	·261
	$\kappa =$	54°·08		$\kappa =$	91°·45		$\kappa =$	17°·38		$\kappa =$	19°·84
M_3	$R =$	·029	P_1	$R =$	·158	μ_2	$R =$	·242	$(M_2K_1)_3$	$R =$	·137
	$\zeta =$	346°·31		$\zeta =$	236°·63		$\zeta =$	65°·08		$\zeta =$	316°·94
	$H =$	·030		$H =$	·158		$H =$	·252		$H =$	·131
	$\kappa =$	341°·93		$\kappa =$	46°·62		$\kappa =$	179°·24		$\kappa =$	17°·29
M_4	$R =$	·737	J_1	$R =$	·018	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·048
	$\zeta =$	275°·56		$\zeta =$	5°·68		$\zeta =$	...		$\zeta =$	29°·85
	$H =$	·768		$H =$	·017		$H =$	...		$H =$	·047
	$\kappa =$	29°·72		$\kappa =$	325°·46		$\kappa =$	...		$\kappa =$	320°·74

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·348	233°·36	·375	12°·68
„ Fortnightly „	·295	104°·37	·231	48°·22
Luni-Solar „ „	·872	278°·59	·890	41°·51
Solar-Annual „	2·762	236°·99	2·762	157°·00
„ Semi-Annual „	1·107	147°·26	1·107	347°·29

PORT BLAIR, 1910.

Short Period Tides.

A_0 = 4·877 feet.

S_1	H = R =	·025	M_6	R =	·003	Q_1	R =	·019	T_2	R =	·082
	κ = ζ =	96°·16		ζ =	61°·56		ζ =	350°·89		ζ =	340°·96
S_2	H = R =	·979		H =	·003		H =	·017		H =	·082
	κ = ζ =	313°·83		κ =	53°·70		κ =	268°·66		κ =	342°·35
S_4	H = R =	·005	M_8	R =	·001	L_2	R =	·045	$(MS)_4$	R =	·014
	κ = ζ =	195°·15		ζ =	188°·13		ζ =	96°·44		ζ =	274°·18
S_6	H = R =	·003		H =	·001		H =	·054		H =	·015
	κ = ζ =	353°·66		κ =	57°·65		κ =	273°·36		κ =	151°·56
S_8	H = R =	·001	O_1	R =	·173	N_2	R =	·381	$(2SM)_2$	R =	·014
	κ = ζ =	355°·60		ζ =	246°·40		ζ =	178°·60		ζ =	28°·07
				H =	·154		H =	·389		H =	·014
				κ =	303°·33		κ =	276°·82		κ =	150°·69
M_1	R =	·007	K_1	R =	·429	λ_2	R =	...	$2N_2$	R =	·046
	ζ =	323°·75		ζ =	142°·08		ζ =	...		ζ =	299°·35
	H =	·004		H =	·400		H =	...		H =	·047
	κ =	10°·53		κ =	325°·34		κ =	...		κ =	258°·41
M_2	R =	1·965	K_2	R =	·313	ν_2	R =	·119	$(M_2N)_4$	R =	·004
	ζ =	41°·71		ζ =	126°·13		ζ =	340°·52		ζ =	118°·74
	H =	2·006		H =	·265		H =	·121		H =	·004
	κ =	279°·09		κ =	312°·07		κ =	236°·22		κ =	94°·34
M_3	R =	·008	P_1	R =	·138	μ_2	R =	·070	$(M_2K_1)_3$	R =	·016
	ζ =	20°·56		ζ =	154°·95		ζ =	166°·13		ζ =	129°·18
	H =	·008		H =	·138		H =	·073		H =	·015
	κ =	16°·63		κ =	324°·95		κ =	280°·89		κ =	189°·83
M_4	R =	·020	J_1	R =	·020	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	349°·04		ζ =	328°·99		ζ =	...		ζ =	296°·05
	H =	·021		H =	·018		H =	...		H =	·005
	κ =	103°·80		κ =	288°·60		κ =	...		κ =	227°·55

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . .	·021	244°·83	·023	23° 99
" Fortnightly "	·073	75°·01	·057	18°·53
Luni-Solar " "	·028	311°·94	·029	74°·56
Solar-Annual "	·226	241°·07	·226	161°·08
" Semi Annual " . .	·042	333° 76	·042	173°·77

OTHER COMPUTATIONS.

The actual times and heights of high and low water for 1910 at 12 ports have been compared with the predicted values published in the tide-tables, and the results tabulated.

SALE OF TIDE-TABLES.

The amount realized on the sale of tide-tables during the year ending September 1911 is Rs. 2,550-9.

DATA FORWARDED TO ENGLAND.

The following data were supplied to the Director, National Physical Laboratory, Teddington, England:—

(*i*) Values of the tidal constants for the tide-tables for 1914, ready for use in the tide predicting machine.

(*ii*) Actual values during 1909 of every high and low water, measured in duplicate from the tidal diagrams at 9 stations, and of tide-pole observations taken during daylight at 3 stations, the latter under the supervision of the Port Officers, and supplied by them to this office.

(*iii*) Comparisons of the above with predicted values for 1909, the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The five tabular statements which are appended, show the percentage and amount of error in the predicted times and heights of high and low water for the year 1910 at 12 stations, as determined by comparisons of the predictions given in the tide-tables with the actual values measured from the tidal diagrams at 9 stations, and from the tide-poles at 3 stations; the former are made in this office, and the latter by the port officials concerned.

No. 1.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	670	36	44	10	7	3
Karāchi	Auto.	706	32	45	11	10	2
Bhāvnagar	T. P.	365	58	42	0	0	0
Bombay { Apollo Bandar	Auto.	704	35	46	9	8	2
Bombay { Prince's Dock	Auto.	696	36	44	9	8	3
Madras	Auto.	705	35	52	8	4	1
Kidderpore	Auto.	704	18	30	15	22	15
Chittagong	T. P.	359	26	26	9	19	20
Akyab	T. P.	364	98	2	0	0	0
Rangoon	Auto.	705	37	32	10	15	6
Moulmein	Auto.	701	21	32	14	18	15
Port Blair	Auto.	705	30	49	10	8	3

WORKING OF THE OBSERVATORIES.

The nine tidal observatories now working were inspected during the year by Mr. Syed Zille Hasnain.

Aden.—As mentioned in last year's report the communication hole at the bottom of the float cylinder had become too large. It was therefore removed during this year's inspection, and a new cylinder which was made by the Port Engineer was fixed in its place. The tide-gauge was found to have worked satisfactorily since the last inspection. It was thoroughly cleaned and overhauled.

Karāchi.—This observatory was found in good order. The communication hole at the bottom of the cylinder was partially blocked by barnacles. It was thoroughly cleaned and the tide-gauge was overhauled and left in working order. There have been no breaks in the tidal registrations during the year.

Apollo Bandar (Bombay).—This observatory has worked well throughout the year. There was one minor interruption in the registration of the tide-gauge.

Prince's Dock (Bombay).—There have been a few short interruptions in the registration of the tide-gauge at this observatory owing to the pencil wire breaking.

Madras.—As the sluice at the bottom of the well of this observatory through which communication between the sea and the well is regulated had not been working satisfactorily for the past two years, steps were taken during this year's inspection to have it removed and replaced by a new one. This work took some days, and the registrations of the tide-gauge were consequently stopped from the 10th to the 21st February 1911. Opportunity was also taken to have the well thoroughly cleaned and repaired. With the exception of the above break, there have been no interruptions in the tidal registrations during the year. The old entrance to the harbour which was immediately south of the observatory has now been closed, and a new entrance has been made in the north arm of the harbour.

Kidderpore.—The tide-gauge at this observatory has worked well throughout the year. There was only one interruption of a few hours in the registrations owing to the stoppage of the driving clock. The inspecting officer found that a good deal of mud had collected near the bottom of the cylinder which was likely to interfere with free communication between the sea and the cylinder. The matter having been brought to the notice of the Deputy Conservator of the Port, the necessary dredging was carried out.

Rangoon.—There have been no breaks in the registrations of the tide-gauge at this observatory during the year. The tide-gauge and the auxiliary instruments were thoroughly cleaned and put in order.

Moulmein.—The tide-gauge at this observatory has worked well during the year, except for a few minor interruptions in its registrations owing to the stoppage of the driving clock. The inspecting officer found the graduated staff inaccurately divided. It was therefore removed and a new graduated staff was prepared and fixed in place of the old one.

Port Blair.—There has been only one interruption of a few hours in the registrations of the tide-gauge at this observatory owing to the stoppage of the driving clock. During the inspection the zero of the graduated staff was found

to differ by 0·1 of a foot from the zero of the tide-gauge. The staff was removed and refixed in its proper position so that its zero is now identical with the zero of the gauge.

TIDAL DIAGRAMS AND DAILY REPORTS.

The tidal diagrams and daily reports have been submitted regularly to the office of this party by the various port officials concerned.

TIDAL CONSTANTS.

The tidal observations at the nine working stations for the year 1910 have been reduced, and the tabulated values of the tidal constants thus determined are appended. There are no arrears.

The following tables give the amplitudes (R) and the epochs (ζ) deduced from the 1910 observations at the various stations; they also give the values of H and κ which are connected with R and ζ in such a way, through the various astronomical quantities involved in the positions of the sun and moon, that if the tidal observations were consistent from year to year H and κ would come out the same from each year's reductions.

ADEN, 1910.

Short Period Tides.

$A_0 = 5{\cdot}836$ feet.

S_1	$H = R =$	·095	M_6	$R =$	·007	Q_1	$R =$	·139	T_2	$R =$	·049
	$\kappa = \zeta =$	178°·73		$\zeta =$	329°·20		$\zeta =$	132°·69		$\zeta =$	290°·68
S_2	$H = R =$	·685		$H =$	·007		$H =$	·125		$H =$	·049
	$\kappa = \zeta =$	241°·96		$\kappa =$	311°·63		$\kappa =$	45°·36		$\kappa =$	291°·94
S_4	$H = R =$	·002	M_8	$R =$	·001	L_2	$R =$	·017	$(MS)_4$	$R =$	·010
	$\kappa = \zeta =$	262°·88		$\zeta =$	74°·75		$\zeta =$	44°·53		$\zeta =$	246°·41
S_6	$H = R =$	·004		$H =$	·001		$H =$	·021		$H =$	·010
	$\kappa = \zeta =$	211°·19		$\kappa =$	291°·32		$\kappa =$	219°·95		$\kappa =$	120°·55
S_8	$H = R =$	·001	O_1	$R =$	·728	N_2	$R =$	·417	$(2SM)_2$	$R =$	·007
	$\kappa = \zeta =$	128°·66		$\zeta =$	343°·04		$\zeta =$	128°·74		$\zeta =$	300°·51
				$H =$	·652		$H =$	·425		$H =$	·007
				$\kappa =$	36°·60		$\kappa =$	221°·99		$\kappa =$	66°·37
M_1	$R =$	·076	K_1	$R =$	1·397	λ_2	$R =$	...	$2N_2$	$R =$	·079
	$\zeta =$	28°·12		$\zeta =$	210°·38		$\zeta =$	...		$\zeta =$	221°·29
	$H =$	·039		$H =$	1·302		$H =$	...		$H =$	·080
	$\kappa =$	73°·29		$\kappa =$	33°·77		$\kappa =$	...		$\kappa =$	173°·64
M_2	$R =$	1·515	K_2	$R =$	·226	ν_2	$R =$	·108	$(M_2N)_4$	$R =$	·008
	$\zeta =$	351°·27		$\zeta =$	53°·72		$\zeta =$	300°·04		$\zeta =$	247°·09
	$H =$	1·546		$H =$	·191		$H =$	·110		$H =$	·008
	$k =$	225°·41		$\kappa =$	239°·92		$\kappa =$	191°·01		$\kappa =$	214°·49
M_3	$R =$	·016	P_1	$R =$	·420	μ_2	$R =$	·069	$(M_2K_1)_3$	$R =$	·015
	$\zeta =$	201°·94		$\zeta =$	223°·50		$\zeta =$	64°·76		$\zeta =$	37°·33
	$H =$	·016		$H =$	·420		$H =$	·072		$H =$	·015
	$\kappa =$	193°·16		$\kappa =$	33°·37		$\kappa =$	173°·05		$\kappa =$	94°·87
M_4	$R =$	·006	J_1	$R =$	·081	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·004
	$\zeta =$	160°·91		$\zeta =$	66°·02		$\zeta =$	...		$\zeta =$	54°·64
	$H =$	·006		$H =$	·073		$H =$	...		$H =$	·004
	$\kappa =$	269°·19		$\kappa =$	27°·50		$\kappa =$	...		$\kappa =$	339°·53

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·023	263°·46	·025	44°·35
„ Fortnightly „	·075	69°·57	·059	16°·59
Luni-Solar „ „ . .	·009	336°·15	·009	102°·00
Solar-Annual „	·309	85°·65	·309	5°·78
„ Semi-Annual „	·086	281°·73	·086	122°·00

KARĀCHI, 1910.

Short Period Tides.

$A_0 = 7{\cdot}233$ feet.

S_1 H = R =	·095	M_6 R =	·044	Q_1 R =	·143	T_2 R =	·087
S_1 κ = ζ =	188°·94	M_6 ζ =	225°·61	Q_1 ζ =	142°·58	T_2 ζ =	10°·68
S_2 H = R =	·973	M_6 H =	·047	Q_1 H =	·128	T_2 H =	·087
S_2 κ = ζ =	322°·68	M_6 κ =	212°·52	Q_1 κ =	57°·59	T_2 κ =	12°·00
S_4 H = R =	·011	M_8 R =	·005	L_2 R =	·033	$(MS)_4$ R =	·035
S_4 κ = ζ =	4°·12	M_8 ζ =	31°·87	L_2 ζ =	103°·95	$(MS)_4$ ζ =	83°·13
S_6 H = R =	·007	M_8 H =	·006	L_2 H =	·040	$(MS)_4$ H =	·036
S_6 κ = ζ =	317°·29	M_8 κ =	254°·41	L_2 κ =	280°·07	$(MS)_4$ κ =	318°·77
S_8 H = R =	·002	O_1 R =	·740	N_2 R =	·607	$(2SM)_2$ R =	·011
S_8 κ = ζ =	74°·06	O_1 ζ =	352°·38	N_2 ζ =	185°·40	$(2SM)_2$ ζ =	333°·67
		O_1 H =	·662	N_2 H =	·619	$(2SM)_2$ H =	·011
		O_1 κ =	47°·50	N_2 κ =	280°·94	$(2SM)_2$ κ =	98°·04
M_1 R =	·090	K_1 R =	1·430	λ_2 R =	...	$2N_2$ R =	·115
M_1 ζ =	36°·56	K_1 ζ =	223°·06	λ_2 ζ =	...	$2N_2$ ζ =	295°·35
M_1 H =	·046	K_1 H =	1·333	λ_2 H =	...	$2N_2$ H =	·118
M_1 κ =	82°·48	K_1 κ =	46°·39	λ_2 κ =	...	$2N_2$ κ =	250°·79
M_2 R =	2·536	K_2 R =	·315	ν_2 R =	·163	$(M_2N)_4$ R =	·019
M_2 ζ =	58°·83	K_2 ζ =	134°·56	ν_2 ζ =	353°·75	$(M_2N)_4$ ζ =	27°·82
M_2 H =	2·590	K_2 H =	·266	ν_2 H =	·166	$(M_2N)_4$ H =	·020
M_2 κ =	294°·46	K_2 κ =	320°·64	ν_2 κ =	246°·91	$(M_2N)_4$ κ =	358°·99
M_3 R =	·035	P_1 R =	·409	μ_2 R =	·070	$(M_2K_1)_3$ R =	·013
M_3 ζ =	352°·30	P_1 ζ =	235°·40	μ_2 ζ =	130°·91	$(M_2K_1)_3$ ζ =	51°·82
M_3 H =	·036	P_1 H =	·409	μ_2 H =	·073	$(M_2K_1)_3$ H =	·013
M_3 κ =	345°·76	P_1 κ =	45°·32	μ_2 κ =	242°·19	$(M_2K_1)_3$ κ =	110°·79
M_4 R =	·014	J_1 R =	·077	R_2 R =	...	$(2M_2K_1)_3$ R =	·029
M_4 ζ =	208°·10	J_1 ζ =	82°·64	R_2 ζ =	...	$(2M_2K_1)_3$ ζ =	64°·26
M_4 H =	·015	J_1 H =	·069	R_2 H =	...	$(2M_2K_1)_3$ H =	·028
M_4 κ =	319°·37	J_1 κ =	43°·26	R_2 κ =	...	$(2M_2K_1)_3$ κ =	352°·20

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·018	138°·97	·019	279°·07
„ Fortnightly „	·046	75°·51	·036	20°·91
Luni-Solar „ „ . . .	·011	356°·43	·011	120°·79
Solar-Annual „	·137	168°·26	·137	88°·33
„ Semi-Annual „ . . .	·147	329°·85	·147	170°·00

BOMBAY (APOLLO BANDAR), 1910.

Short Period Tides.

A_0 = 10 204 feet.

S_1	$H = R =$	·062	M_6	$R =$	·016	Q_1	$R =$	·139	T_2	$R =$	·163
	$\kappa = \zeta =$	196°·78		$\zeta =$	26°·57		$\zeta =$	145°·18		$\zeta =$	44°·97
S_2	$H = R =$	1·555		$H =$	·017		$H =$	·125		$H =$	·163
	$\kappa = \zeta =$	2°·30		$\kappa =$	14°·66		$\kappa =$	60°·82		$\kappa =$	46°·31
S_4	$H = R =$	·014	M_8	$R =$	·009	L_2	$R =$	·016	$(MS)_4$	$R =$	·085
	$\kappa = \zeta =$	251°·31		$\zeta =$	114°·57		$\zeta =$	332°·77		$\zeta =$	146°·35
S_6	$H = R =$	·002		$H =$	·010		$H =$	·019		$H =$	·086
	$\kappa = \zeta =$	190°·31		$\kappa =$	338°·70		$\kappa =$	149°·07		$\kappa =$	22°·38
S_8	$H = R =$	·002	O_1	$R =$	·721	N_2	$R =$	·949	$(2SM)_2$	$R =$	·036
	$\kappa = \zeta =$	115°·46		$\zeta =$	352°·78		$\zeta =$	218°·37		$\zeta =$	334°·00
				$H =$	·645		$H =$	·969		$H =$	·037
				$\kappa =$	48°·31		$\kappa =$	314°·52		$\kappa =$	97°·97
M_1	$R =$	·094	K_1	$R =$	1·496	λ_2	$R =$	...	$2N_2$	$R =$	·118
	$\zeta =$	35°·39		$\zeta =$	221°·68		$\zeta =$	...		$\zeta =$	334°·56
	$H =$	·048		$H =$	1·394		$H =$	...		$H =$	·120
	$\kappa =$	81°·50		$\kappa =$	45°·00		$\kappa =$	...		$\kappa =$	290°·82
M_2	$R =$	3·853	K_2	$R =$	·481	ν_2	$R =$	·240	$(M_2N)_4$	$R =$	·017
	$\zeta =$	93°·96		$\zeta =$	171°·68		$\zeta =$	23°·08		$\zeta =$	240°·91
	$H =$	3·934		$H =$	·407		$H =$	·245		$H =$	·018
	$\kappa =$	329°·99		$\kappa =$	357°·73		$\kappa =$	276°·82		$\kappa =$	213°·09
M_3	$R =$	·074	P_1	$R =$	·404	μ_2	$R =$	·205	$(M_2K_1)_3$	$R =$	·087
	$\zeta =$	23°·12		$\zeta =$	234°·98		$\zeta =$	181°·08		$\zeta =$	148°·61
	$H =$	·076		$H =$	·404		$H =$	·214		$H =$	·083
	$\kappa =$	17°·16		$\kappa =$	44°·92		$\kappa =$	293°·14		$\kappa =$	207°·96
M_4	$R =$	·082	J_1	$R =$	·080	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·064
	$\zeta =$	187°·34		$\zeta =$	88°·64		$\zeta =$	...		$\zeta =$	135°·07
	$H =$	·085		$H =$	·072		$H =$	...		$H =$	·062
	$\kappa =$	299°·41		$\kappa =$	49°·03		$\kappa =$	...		$\kappa =$	63°·81

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·009	334°·26	·010	114°·14
„ Fortnightly „	·043	73°·05	·034	18°·03
Luni-Solar „ „	·024	251°·94	·025	15°·91
Solar-Annual „	·057	41°·04	·057	324°·10
„ Semi-Annual „	·135	357°·13	·135	197°·25

BOMBAY (PRINCE'S DOCK), 1910.

Short Period Tides.

A_0 = 8·201 feet.

S_1	$H = R =$	·085	M_6	$R =$	·012	Q_1	$R =$	·143	T_2	$R =$	·167
	$\kappa = \zeta =$	190°·85		$\zeta =$	219°·14		$\zeta =$	145°·74		$\zeta =$	45°·00
S_2	$H = R =$	1·594		$H =$	·013		$H =$	·128		$H =$	·167
	$\kappa = \zeta =$	5°·58		$\kappa =$	207°·24		$\kappa =$	61°·38		$\kappa =$	46°·34
S_4	$H = R =$	·020	M_8	$R =$	·002	L_2	$R =$	·023	$(MS)_4$	$R =$	·117
	$\kappa = \zeta =$	218°·21		$\zeta =$	198°·44		$\zeta =$	10°·73		$\zeta =$	168°·09
S_6	$H = R =$	·004		$H =$	·003		$H =$	·028		$H =$	·120
	$\kappa = \zeta =$	181°·51		$\kappa =$	62°·56		$\kappa =$	187°·02		$\kappa =$	44°·12
S_8	$H = R =$	·002	O_1	$R =$	·735	N_2	$R =$	·968	$(2SM)_2$	$R =$	·041
	$\kappa = \zeta =$	184°·76		$\zeta =$	353°·23		$\zeta =$	221°·49		$\zeta =$	352°·38
				$H =$	·657		$H =$	·989		$H =$	·041
				$\kappa =$	48°·76		$\kappa =$	317°·63		$\kappa =$	116°·35
M_1	$R =$	·101	K_1	$R =$	1·504	λ_2	$R =$	...	$2N_2$	$R =$	·109
	$\zeta =$	35°·00		$\zeta =$	222°·38		$\zeta =$	...		$\zeta =$	338°·12
	$H =$	·052		$H =$	1·402		$H =$	...		$H =$	·111
	$\kappa =$	81°·11		$\kappa =$	45°·70		$\kappa =$	...		$\kappa =$	204°·38
M_2	$R =$	3·958	K_2	$R =$	·497	ν_2	$R =$	·234	$(M_2N)_4$	$R =$	·007
	$\zeta =$	96°·41		$\zeta =$	175°·95		$\zeta =$	23°·94		$\zeta =$	124°·38
	$H =$	4·041		$H =$	·421		$H =$	·239		$H =$	·008
	$\kappa =$	332°·44		$\kappa =$	2°·00		$\kappa =$	276°·67		$\kappa =$	96°·56
M_3	$R =$	·077	P_1	$R =$	·409	μ_2	$R =$	·211	$(M_2K_1)_3$	$R =$	·091
	$\zeta =$	28°·68		$\zeta =$	235°·76		$\zeta =$	188°·58		$\zeta =$	136°·10
	$H =$	·079		$H =$	·409		$H =$	·220		$H =$	·086
	$\kappa =$	22°·68		$\kappa =$	45°·70		$\kappa =$	300°·65		$\kappa =$	195°·45
M_4	$R =$	·087	J_1	$R =$	·082	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·081
	$\zeta =$	225°·10		$\zeta =$	87°·97		$\zeta =$	...		$\zeta =$	150°·44
	$H =$	·091		$H =$	·074		$H =$	...		$H =$	·078
	$\kappa =$	337°·16		$\kappa =$	48°·36		$\kappa =$	...		$\kappa =$	79°·18

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·016	265°·64	·017	45°·53
„ Fortnightly „	·051	77°·07	·040	22°·04
Luni-Solar „ „	·041	247°·61	·042	11°·57
Solar-Annual „	·053	50°·11	·053	330°·17
„ Semi-Annual „	·146	353°·48	·146	193°·60

MADRAS, 1910.

Short Period Tides.

A_0 = 2·412 feet.

S_1 H = R =	·030	M_6 R =	·003	Q_1 R =	·002	T_2 R =	·028
S_1 $\kappa = \zeta$ =	94°·90	M_6 ζ =	151°·70	Q_1 ζ =	113°·20	T_2 ζ =	319°·15
S_2 H = R =	·461	M_6 H =	·004	Q_1 H =	·001	T_2 H =	·028
S_2 $\kappa = \zeta$ =	269°·76	M_6 κ =	141°·30	Q_1 κ =	29°·63	T_2 κ =	320°·51
S_4 H = R =	·001	M_8 R =	·001	L_2 R =	·047	$(MS)_4$ R =	·004
S_4 $\kappa = \zeta$ =	345°·96	M_8 ζ =	257°·47	L_2 ζ =	93°·24	$(MS)_4$ ζ =	79°·29
S_6 H = R =	·002	M_8 H =	·001	L_2 H =	·056	$(MS)_4$ H =	·004
S_6 $\kappa = \zeta$ =	81°·03	M_8 κ =	123°·61	L_2 κ =	269°·76	$(MS)_4$ κ =	315°·82
S_8 H = R =	·001	O_1 R =	·106	N_2 R =	·233	$(2SM)_2$ R =	·020
S_8 $\kappa = \zeta$ =	23°·96	O_1 ζ =	268°·37	N_2 ζ =	140°·52	$(2SM)_2$ ζ =	106°·47
		O_1 H =	·095	N_2 H =	·238	$(2SM)_2$ H =	·020
		O_1 κ =	324°·42	N_2 κ =	237°·44	$(2SM)_2$ κ =	229°·94
M_1 R =	·007	K_1 R =	·324	λ_2 R =	...	$2N_2$ R =	·043
M_1 ζ =	354°·45	K_1 ζ =	152°·75	λ_2 ζ =	...	$2N_2$ ζ =	253°·60
M_1 H =	·004	K_1 H =	·302	λ_2 H =	...	$2N_2$ H =	·044
M_1 κ =	40°·81	K_1 κ =	336°·05	λ_2 κ =	...	$2N_2$ κ =	210°·90
M_2 R =	1·053	K_2 R =	·148	ν_2 R =	·061	$(M_2N)_4$ R =	·003
M_2 ζ =	4°·31	K_2 ζ =	84°·91	ν_2 ζ =	312°·26	$(M_2N)_4$ ζ =	151°·82
M_2 H =	1·075	K_2 H =	·126	ν_2 H =	·063	$(M_2N)_4$ H =	·004
M_2 κ =	240°·85	K_2 κ =	270°·92	ν_2 κ =	206°·73	$(M_2N)_4$ κ =	125°·28
M_3 R =	·003	P_1 R =	·096	μ_2 R =	·040	$(M_2K_1)_3$ R =	·010
M_3 ζ =	52°·70	P_1 ζ =	168°·16	μ_2 ζ =	54°·89	$(M_2K_1)_3$ ζ =	86°·39
M_3 H =	·003	P_1 H =	·096	μ_2 H =	·041	$(M_2K_1)_3$ H =	·009
M_3 κ =	47°·50	P_1 κ =	338°·12	μ_2 κ =	167°·96	$(M_2K_1)_3$ κ =	146°·22
M_4 R =	·003	J_1 R =	·013	R_2 R =	...	$(2M_2K_1)_3$ R =	·002
M_4 ζ =	94°·40	J_1 ζ =	215°·13	R_2 ζ =	...	$(2M_2K_1)_3$ ζ =	28°·07
M_4 H =	·003	J_1 H =	·012	R_2 H =	...	$(2M_2K_1)_3$ H =	·002
M_4 κ =	207°·47	J_1 κ =	175°·23	R_2 κ =	...	$(2M_2K_1)_3$ κ =	317°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·058	218°·58	·063	358°·19
„ Fortnightly „	·055	48°·04	·043	352°·48
Luni-Solar „ „	·024	21°·15	·025	144°·61
Solar-Annual „	·504	278°·46	·504	198°·49
„ Semi-Annual „	·235	267°·78	·235	107°·85

KIDDERPORE, 1910.

Short Period Tides.

$A_0 = 10{\cdot}895$ feet.

S_1	$H=R=$	·090	M_6	$R=$	·165	Q_1	$R=$	·016	T_2	$R=$	·203
	$\kappa=\zeta=$	192°·21		$\zeta=$	321°·19		$\zeta=$	100°·01		$\zeta=$	156°·39
S_2	$H=R=$	1·553		$H=$	·175		$H=$	·014		$H=$	·203
	$\kappa=\zeta=$	95°·61		$\kappa=$	312°·43		$\kappa=$	17°·31		$\kappa=$	157°·77
S_4	$H=R=$	·107	M_8	$R=$	·080	L_2	$R=$	·168	$(MS)_4$	$R=$	·693
	$\kappa=\zeta=$	106°·65		$\zeta=$	28°·89		$\zeta=$	232°·54		$\zeta=$	194°·29
S_6	$H=R=$	·008		$H=$	·087		$H=$	·201		$H=$	·708
	$\kappa=\zeta=$	49°·48		$\kappa=$	257°·21		$\kappa=$	49°·32		$\kappa=$	71°·37
S_8	$H=R=$	·001	O_1	$R=$	·233	N_2	$R=$	·675	$(2SM)_2$	$R=$	·066
	$\kappa=\zeta=$	321°·34		$\zeta=$	325°·76		$\zeta=$	306°·71		$\zeta=$	240°·19
				$H=$	·209		$H=$	·689		$H=$	·068
				$\kappa=$	22°·38		$\kappa=$	44°·47		$\kappa=$	3°·11
M_1	$R=$	·044	K_1	$R=$	·454	λ_2	$R=$	...	$2N_2$	$R=$	·096
	$\zeta=$	137°·79		$\zeta=$	229°·86		$\zeta=$	...		$\zeta=$	351°·10
	$H=$	·022		$H=$	·423		$H=$	...		$H=$	·098
	$\kappa=$	184°·42		$\kappa=$	53°·14		$\kappa=$	...		$\kappa=$	309°·54
M_2	$R=$	3·666	K_2	$R=$	·550	ν_2	$R=$	·286	$(M_2N)_4$	$R=$	·250
	$\zeta=$	177°·60		$\zeta=$	265°·49		$\zeta=$	122°·11		$\zeta=$	45°·00
	$H=$	3·743		$H=$	·465		$H=$	·292		$H=$	·261
	$\kappa=$	54°·08		$\kappa=$	91°·45		$\kappa=$	17°·38		$\kappa=$	19°·84
M_3	$R=$	·029	P_1	$R=$	·158	μ_2	$R=$	·242	$(M_2K_1)_3$	$R=$	·137
	$\zeta=$	346°·31		$\zeta=$	236°·63		$\zeta=$	65°·08		$\zeta=$	316°·94
	$H=$	·030		$H=$	·158		$H=$	·252		$H=$	·131
	$\kappa=$	341°·93		$\kappa=$	46°·62		$\kappa=$	179°·24		$\kappa=$	17°·29
M_4	$R=$	·737	J_1	$R=$	·018	R_2	$R=$	...	$(2M_2K_1)_3$	$R=$	·048
	$\zeta=$	275°·56		$\zeta=$	5°·68		$\zeta=$	...		$\zeta=$	29°·85
	$H=$	·768		$H=$	·017		$H=$	...		$H=$	·047
	$\kappa=$	29°·72		$\kappa=$	325°·46		$\kappa=$	...		$\kappa=$	320°·74

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·348	233°·36	·375	12°·68
„ Fortnightly „	·295	104°·37	·231	48°·22
Luni-Solar „ „	·872	278°·59	·890	41°·51
Solar-Annual „	2·762	236°·99	2·762	157°·00
„ Semi-Annual „	1·107	147°·26	1·107	347°·29

PORT BLAIR, 1910.

Short Period Tides.

$A_0 = 4{\cdot}877$ feet.

S_1	H = R =	·025	M_6	R =	·003	Q_1	R =	·019	T_2	R =	·082
	κ = ζ =	96°·16		ζ =	61°·56		ζ =	350°·89		ζ =	340°·96
S_2	H = R =	·979		H =	·003		H =	·017		H =	·082
	κ = ζ =	313°·83		κ =	53°·70		κ =	268°·66		κ =	342°·35
S_4	H = R =	·005	M_8	R =	·001	L_2	R =	·045	$(MS)_4$	R =	·014
	κ = ζ =	195°·15		ζ =	188°·13		ζ =	96°·44		ζ =	274°·18
S_6	H = R =	·003		H =	·001		H =	·054		H =	·015
	κ = ζ =	353°·66		κ =	57°·65		κ =	273°·36		κ =	151°·56
S_8	H = R =	·001	O_1	R =	·173	N_2	R =	·381	$(2SM)_2$	R =	·014
	κ = ζ =	355°·60		ζ =	246°·40		ζ =	178°·60		ζ =	28°·07
				H =	·154		H =	·389		H =	·014
				κ =	303°·33		κ =	276°·82		κ =	150°·69
M_1	R =	·007	K_1	R =	·429	λ_2	R =	...	$2N_2$	R =	·046
	ζ =	323°·75		ζ =	142°·08		ζ =	...		ζ =	299°·35
	H =	·004		H =	·400		H =	...		H =	·047
	κ =	10°·53		κ =	325°·34		κ =	...		κ =	258°·41
M_2	R =	1·965	K_2	R =	·313	ν_2	R =	·119	$(M_2N)_4$	R =	·004
	ζ =	41°·71		ζ =	126°·13		ζ =	340°·52		ζ =	118°·74
	H =	2·006		H =	·265		H =	·121		H =	·004
	κ =	279°·09		κ =	312°·07		κ =	236°·22		κ =	94°·34
M_3	R =	·008	P_1	R =	·138	μ_2	R =	·070	$(M_2K_1)_3$	R =	·016
	ζ =	20°·56		ζ =	154°·95		ζ =	166°·13		ζ =	129°·18
	H =	·008		H =	·138		H =	·073		H =	·015
	κ =	16°·63		κ =	324°·95		κ =	280°·89		κ =	189°·83
M_4	R =	·020	J_1	R =	·020	R_2	R =	...	$(2M_2K_1)_3$	R =	·005
	ζ =	349°·04		ζ =	328°·99		ζ =	...		ζ =	296°·05
	H =	·021		H =	·018		H =	...		H =	·005
	κ =	103°·80		κ =	288°·60		κ =	...		κ =	227°·55

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . .	·021	244°·83	·023	23° 99
" Fortnightly "	·073	75°·01	·057	18°·53
Luni-Solar " "	·028	311°·94	·029	74°·56
Solar-Annual "	·226	241°·07	·226	161°·08
" Semi Annual " . .	·042	333° 76	·042	173°·77

OTHER COMPUTATIONS.

The actual times and heights of high and low water for 1910 at 12 ports have been compared with the predicted values published in the tide-tables, and the results tabulated.

SALE OF TIDE-TABLES.

The amount realized on the sale of tide-tables during the year ending September 1911 is Rs. 2,550-9.

DATA FORWARDED TO ENGLAND.

The following data were supplied to the Director, National Physical Laboratory, Teddington, England:—

(*i*) Values of the tidal constants for the tide-tables for 1914, ready for use in the tide predicting machine.

(*ii*) Actual values during 1909 of every high and low water, measured in duplicate from the tidal diagrams at 9 stations, and of tide-pole observations taken during daylight at 3 stations, the latter under the supervision of the Port Officers, and supplied by them to this office.

(*iii*) Comparisons of the above with predicted values for 1909, the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The five tabular statements which are appended, show the percentage and amount of error in the predicted times and heights of high and low water for the year 1910 at 12 stations, as determined by comparisons of the predictions given in the tide-tables with the actual values measured from the tidal diagrams at 9 stations, and from the tide-poles at 3 stations; the former are made in this office, and the latter by the port officials concerned.

No. 1.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	670	36	44	10	7	3
Karāchi	Auto.	706	32	45	11	10	2
Bhāvnagar	T. P.	365	58	42	0	0	0
Bombay { Apollo Bandar	Auto.	704	35	46	9	8	2
Bombay { Prince's Dock	Auto.	696	36	44	9	8	3
Madras	Auto.	705	35	52	8	4	1
Kidderpore	Auto.	704	18	30	15	22	15
Chittagong	T. P.	359	26	26	9	19	20
Akyab	T. P.	364	98	2	0	0	0
Rangoon	Auto.	705	37	32	10	15	6
Moulmein	Auto.	701	21	32	14	18	15
Port Blair	Auto.	705	30	49	10	8	3

No. 2.

Statement showing the percentage and the amount of the errors in the predicted times of low water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	667	36	40	10	9	5
Karāchi	Auto.	705	34	45	9	9	3
Bhāvnagar	T. P.	365	54	45	0	1	0
Bombay { Apollo Bandar	Auto.	705	38	41	10	8	3
Bombay { Prince's Dock	Auto.	698	38	43	10	7	2
Madras	Auto.	705	44	47	5	3	1
Kidderpore	Auto.	706	16	33	13	21	17
Chittagong	T. P.	361	26	28	12	15	19
Akyab	T. P.	365	97	3	0	0	0
Rangoon	Auto.	705	25	38	15	17	5
Moulmein	Auto.	705	17	28	12	18	25
Port Blair	Auto.	703	44	45	7	3	1

No. 3.

Statement showing the percentage and the amount of the errors in the predicted heights of high water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	670	6·7	93	7	...	...
Karāchi	Auto.	706	9·3	78	20	2	...
Bhāvnagar	T. P.	365	31·4	61	31	6	2
Bombay { Apollo Bandar	Auto.	704	13·9	68	27	4	1
Bombay { Prince's Dock	Auto.	696	13·9	70	24	6	...
Madras	Auto.	705	3·5	72	26	2	...
Kidderpore	Auto.	704	11·7	34	25	17	24
Chittagong	T. P.	359	13·3	34	25	18	23
Akyab	T. P.	364	8·3	85	14	1	...
Rangoon	Auto.	705	16·4	51	26	14	9
Moulmein	Auto.	701	12·7	30	24	20	26
Port Blair	Auto.	705	6·6	90	10	...	...

No. 4.

Statement showing the percentage and the amount of the errors in the predicted heights of low water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Mean range at springs, in feet.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
				Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	667	6·7	95	5	...	...
Karāchi	Auto.	705	9·3	84	15	1	...
Bhāvnagar	T. P.	365	31·4	57	33	9	1
Bombay { Apollo Bandar	Auto.	705	13·9	75	21	4	...
Bombay { Prince's Dock	Auto.	698	13·9	70	25	4	1
Madras	Auto.	705	3·5	76	23	1	...
Kidderpore	Auto.	706	11·7	43	28	15	14
Chittagong	T. P.	361	13·3	36	26	20	18
Akyab	T. P.	365	8·3	88	12	...	...
Rangoon	Auto.	705	16·4	42	29	16	13
Moulmein	Auto.	705	12·7	48	24	15	13
Port Blair	Auto.	703	6·6	97	3	...	...

No. 5.

Table of average errors in the predicted times and heights of high and low water at the several Tidal Stations for the year 1910.

Stations.	Automatic or tide pole observations.	Mean range at springs, in feet.	AVERAGE ERRORS.					
			Of time in minutes.		Of height in terms of the range.		Of height in inches.	
			H. W.	L. W.	H. W.	L. W.	H. W.	L. W.
Open coast.								
Aden	Auto.	6·7	10	11	·025	·025	2	2
Karāchi	Auto.	9·3	10	10	·027	·027	3	3
Bhāvnagar	T. P.	31·4	5	6	·011	·013	4	5
Bombay { Apollo Bandar	Auto.	13·9	10	10	·018	·018	3	3
Bombay { Prince's Dock	Auto.	13·9	10	9	·024	·018	4	3
Madras	Auto.	3·5	9	8	·071	·071	3	3
Akyab	T. P.	8·3	1	1	·020	·020	2	2
Port Blair	Auto.	6·6	11	8	·025	·025	2	2
General Mean	...	...	8	8	·028	·027	...	...
Riverain.								
Kidderpore	Auto.	11·7	18	18	·057	·050	8	7
Chittagong	T. P.	13·3	19	18	·050	·044	8	7
Rangoon	Auto.	16·4	12	13	·030	·030	6	6
Moulmein	Auto.	12·7	17	21	·059	·039	9	6
General Mean	...	...	17	18	·049	·041	...	...

The foregoing statements for the year 1910 may be thus summarised:—

Percentage of time predictions within 15 minutes of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	81	83
	2 " " " tide pole . .	100	100
Riverain stations.	3 " " " S. R. tide gauge .	57	52
	1 " " " tide pole . .	52	55

Percentage of height predictions within 8 inches of actuals.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	98	98
	2 " " " tide pole . .	96	95
Riverain stations.	3 " " " S. R. tide gauge .	63	71
	1 " " " tide pole . .	59	62

Percentage of height predictions within one-tenth of mean range at springs.

		High water.	Low water.
		Per cent.	Per cent.
Open coast stations.	6 at which predictions were tested by S. R. tide gauge .	95	96
	2 " " " tide pole . .	100	100
Riverain stations.	3 " " " S. R. tide gauge .	89	94
	1 " " " tide pole . .	91	95

The predictions for the riverain stations for the year 1910 were compared with those for the previous year, with following results:—

The predictions for high and low water times for 1910 are worse for Moulmein and Chittagong and about the same for Kidderpore and Rangoon; for high and low water heights the predictions for 1910 are worse for Kidderpore and about the same for the other three stations. The greatest difference between the actual and predicted heights of low water for 1910 at the riverain stations was as follows:—

Kidderpore .	2′ 10″	on 19th October 1910, actuals being higher.
Chittagong .	1′ 11″	on 5th July 1910, actuals being higher.
Rangoon . .	2′ 7″	on 22nd July 1910, actuals being lower.
Moulmein .	6″	on 22nd July 1910, actuals being higher.

PART V.—LEVELLING.

LEVELLING OF PRECISION.

By Colonel S. G. Burrard, C.S.I., R.E., F.R.S.

The three volumes, numbered XIX, XIXA, and XIXB respectively, which contain the complete account of the levelling of precision executed from 1858 down to the end of the survey year 1908-09, have now been published.

Volume XIX contains a history of the work, a description of the methods and a discussion of the results, while the descriptions and heights of the bench-marks are contained in Volumes XIXA and B, the former dealing with the southern parts of India and the latter with the northern parts.

The most northerly lines included in Volume XIXA are those that join Bombay to Sironj *viâ* Nāndgaon, and Nāndgaon to False Point *viâ* Raipur, Bilāspur, and Cuttack.

The heights contained in these volumes are those obtained after the final simultaneous adjustment of all the lines of levels to the mean level of the sea at nine selected tidal observatories. These values supersede those contained in the various levelling pamphlets that have been issued from time to time. All levelling pamphlets, published prior to 1911 are now obsoleté, and data should not be taken from them.

In Volumes XIXA and B, each bench-mark is given two numbers, a geodetic number which refers to its position on the line to which it belongs, and a topographical number which refers it to the degree sheet in which it lies. Within the limits of each degree sheet the bench-marks are numbered consecutively, so that its serial number, with the distinguishing number and letter of the degree sheet, completely defines a bench-mark. These reference numbers are written thus, $\frac{\text{B. M. } 25}{40\text{ C}}$, that is to say, the 25th bench-mark in degree sheet C of millionth sheet 40.

In Volumes XIXA and XIXB, two values of the height of each bench-mark are given, namely, the *dynamic height* and the *orthometric height*. The difference between them and the meaning of both are explained on pages 99—108 of Volume XIX.

The orthometric height is that which should be used by engineers, and should therefore be given on maps.

The number of bench-marks enumerated in the volumes is very large, but it is to be feared that many are no longer in existence, or are now untraceable, owing to the objects with reference to which their positions were described having been altered or removed.

Officers should inform the Superintendent, Trigonometrical Surveys, of the condition of all the important bench-marks which they come across.

The primary bench-marks should always be reported upon, namely, Rock-cut, Engraved, Interred, Standard, and Principal stations of triangulation (*vide* Volume XIX, pages 65-66). Other less important marks need not be reported upon unless they are found to have been damaged, or cannot be found at all, or if there is reason to suspect that they have suffered a change in altitude.

Tidal officers should report to the Superintendent, Trigonometrical Surveys, whether the bench-marks at ports require renovation.

The lines of levelling that are now being run are partly to cover new ground, such as Assam and Burma, and partly to provide additional points within the large areas which are not crossed by any of the old lines.

The new lines of levelling will be so designed that they may, when complete, form an independent level net, connected to sea level at a greater number of points than the old one, and capable of an independent simultaneous adjustment. In the meantime, and until such time as they are complete, the new lines will, whenever possible, start from and close on bench-marks of the old net, and all published heights will be in the same terms as those contained in Volumes XIX A and B.

No. 17 PARTY.

(*Vide* Index Map 10).

BY LIEUTENANT-COLONEL G. P. LENOX-CONYNGHAM, R.E.

PERSONNEL.

Imperial Officers.

Major J. M. Burn, R.E., in charge from 1st to 18th October 1910.

Mr. J. Eccles, in charge from 19th October to 13th November 1910.

Lieutenant-Colonel P. J. Gordon, I.A., in charge from 14th November 1910 to 13th March 1911.

Lieutenant-Colonel G. P. Lenox-Conyngham, R.E., in charge from 14th March to 30th September 1911.

(*The personnel of the detachments and the details of the work done are given in the separate reports.*)

During the year another binocular level, *viz.*, No. 6728 by Messrs. Bausch, Lomb and Saegmuller, was received.

The party now possesses 9 of these instruments. They all are very similar in appearance, but they are not all equally satisfactory. The object glasses of two, namely Nos. 2625 and 6728, are very indifferent; they have such large spherical aberration that it is impossible to find any state of focus in which parallax is wholly eliminated. Most of the instruments also have a serious defect in that the eye end cannot be racked out far enough to allow of objects nearer than about 40 feet being focussed. On steep slopes it is frequently necessary to take shorter shots than this, and consequently it has been necessary to equip each detachment with another instrument of different make for use on steep ground.

Level No. 3 by Messrs. T. Cooke and Sons is much superior to the others in both the above respects.

The question of the behaviour of the levelling staves under changes of the atmospheric conditions has been closely watched, but no satisfactory result has been obtained. The staves undoubtedly expand when the air becomes moist, but the action is slow and it is impossible to find any relation between the moisture at any instant and the length of the staff. It would be a great advantage if a staff could be constructed which would be free from the effects of moisture. Experiments on aluminium and steel have been instituted, and it is hoped that something satisfactory may be devised. In the meantime the comparisons with the standard steel bars are being made as far as possible during the course of the field work, and not only after returning to camp, so as to obtain as near an approximation as possible to the actual length during the levelling.

A noteworthy point of the work of the past year is that the hills to the west of the Indus are now connected to the level net, so that means now exist of detecting any change in the relative heights of the Himālayas and an offshoot of the Sulaimān Mountains. The connection with the western hills

is as yet meagre, but that of the Himalayas is satisfactory being effected by seven lines of levels, namely :—

1. Silīgurī to Tindhāria.
2. Bareilly to Nainī Tāl.
3. Hardwār to Lansdowne.
4. Sahāranpur to Mussoorie.
5. Ambāla to Solon.
6. Lahore to Dharmkot.
7. Rāwalpindi to Murree.

It is desirable that the levelling should be extended from Jacobābād into the Baluchistān Hills when an opportunity occurs.

The following Standard Bench-marks were connected during the year :—

Ahmednagar.
Dhubri.
Gauhāti.
Dibrugarh.

No. 1 Levelling Detachment.

The following programme of work was allotted to the detachment :—

PERSONNEL.
Provincial Officers.
Mr. E. H. Corridon.
Mr. D. H. Luxa.
Mr. T. F. Kitchen.
Lower Subordinate Service.
3 Recorders.

(1) Levelling to connect a number of supplementary rock-cut protected bench-marks :—

(*a*) On the Thal Ghāt on the Kalyān-Nāndgaon line of levels.

(*b*) At Bombay.

(*c*) On the Bor-Ghāt on the Kalyān-Kedgaon line of levels.

(2) Levelling from Poona to Ahmednagar along the road *viâ* Sirūr.

(3) Levelling from Marmagao along the railway line *viâ* Londa Junction to Belgaum.

(4) Revisionary levelling from Belgaum to Hubli by road *viâ* Dhārwār.

(5) Levelling from Belgaum to Bāgalkot by road *viâ* Kalādgi.

Table I shows the discrepancies between the old and the new values of the heights of those bench-marks which are common to the lines of this season and to previous operations. Discrepancies which call for remark are to be found in the neighbourhood of Igatpuri and at Marmagao. At the latter place there is a set of four bench-marks which seem to have sunk by amounts varying from 0·8 of an inch to 2·2 inches. The agreement between the old and new values of the remaining twelve bench-marks between Marmagao and Margao is so good that it may be concluded with considerable confidence that these four bench-marks have proved untrustworthy.

On the Igatpuri-Kāsāra line the case is different. Here we have five bench-marks near Kāsāra which agree well and give us confidence that no movement has taken place since the levelling of 1877-78. The next four bench-marks are not altogether trustworthy as their identity is open to some

MADRAS, 1910.

Short Period Tides.

A_0 = 2·412 feet.

S_1	H = R =	·030	M_6	R =	·003	Q_1	R =	·002	T_2	R =	·028
	κ = ζ =	94°·90		ζ =	151°·70		ζ =	113°·20		ζ =	319°·15
S_2	H = R =	·461		H =	·004		H =	·001		H =	·028
	κ = ζ =	269°·76		κ =	141°·30		κ =	29°·63		κ =	320°·51
S_4	H = R =	·001	M_8	R =	·001	L_2	R =	·017	$(MS)_4$	R =	·004
	κ = ζ =	345°·96		ζ =	257°·47		ζ =	93°·24		ζ =	79°·29
S_6	H = R =	·002		H =	·001		H =	·056		H =	·004
	κ = ζ =	81°·03		κ =	123°·61		κ =	269°·76		κ =	315°·82
S_8	H = R =	·001	O_1	R =	·106	N_2	R =	·233	$(2SM)_2$	R =	·020
	κ = ζ =	23°·96		ζ =	268°·37		ζ =	140°·52		ζ =	106°·47
				H =	·095		H =	·238		H =	·020
				κ =	324°·42		κ =	237°·44		κ =	229°·94
M_1	R =	·007	K_1	R =	·324	λ_2	R =	...	$2N_2$	R =	·043
	ζ =	354°·45		ζ =	152°·75		ζ =	...		ζ =	253°·60
	H =	·004		H =	·302		H =	...		H =	·044
	κ =	40°·81		κ =	336°·05		κ =	...		κ =	210°·90
M_2	R =	1·053	K_2	R =	·148	ν_2	R =	·061	$(M_2N)_4$	R =	·003
	ζ =	4°·31		ζ =	84°·91		ζ =	312°·26		ζ =	151°·82
	H =	1·075		H =	·126		H =	·063		H =	·004
	κ =	240°·85		κ =	270°·92		κ =	206°·73		κ =	125°·28
M_3	R =	·003	P_1	R =	·096	μ_2	R =	·040	$(M_2K_1)_3$	R =	·010
	ζ =	52°·70		ζ =	168°·16		ζ =	54°·89		ζ =	86°·39
	H =	·003		H =	·096		H =	·041		H =	·009
	κ =	47°·50		κ =	338°·12		κ =	167°·96		κ =	146°·22
M_4	R =	·003	J_1	R =	·013	R_2	R =	...	$(2M_2K_1)_3$	R =	·002
	ζ =	94°·40		ζ =	215°·13		ζ =	...		ζ =	28°·07
	H =	·003		H =	·012		H =	...		H =	·002
	κ =	207°·47		κ =	175°·23		κ =	...		κ =	317°·84

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·058	218°·58	·063	358°·19
„ Fortnightly „	·055	48°·04	·043	352°·48
Luni-Solar „ „	·024	21°·15	·025	144°·61
Solar-Annual „	·504	278°·46	·504	198°·49
„ Semi-Annual „	·235	267°·78	·235	107°·85

KIDDERPORE, 1910.

Short Period Tides.

$A_0 = 10{\cdot}895$ feet.

S_1	H = R =	·090	M_6	R =	·165	Q_1	R =	·016	T_2	R =	·203
	κ = ζ =	192°·21		ζ =	321°·19		ζ =	100°·01		ζ =	156°·39
S_2	H = R =	1·553		H =	·175		H =	·014		H =	·203
	κ = ζ =	95°·61		κ =	312°·43		κ =	17°·31		κ =	157°·77
S_4	H = R =	·107	M_8	R =	·080	L_2	R =	·168	$(MS)_4$	R =	·693
	κ = ζ =	106°·65		ζ =	28°·89		ζ =	232°·54		ζ =	194°·29
S_6	H = R =	·008		H =	·087		H =	·201		H =	·708
	κ = ζ =	49°·48		κ =	257°·21		κ =	49°·32		κ =	71°·37
S_8	H = R =	·001	O_1	R =	·233	N_2	R =	·675	$(2SM)_2$	R =	·066
	κ = ζ =	321°·34		ζ =	325°·76		ζ =	306°·71		ζ =	240°·19
				H =	·209		H =	·689		H =	·068
				κ =	22°·38		κ =	44°·47		κ =	3°·11
M_1	R =	·044	K_1	R =	·454	λ_2	R =	...	$2N_2$	R =	·096
	ζ =	137°·79		ζ =	229°·86		ζ =	...		ζ =	351°·10
	H =	·022		H =	·423		H =	...		H =	·098
	κ =	184°·42		κ =	53°·14		κ =	...		κ =	309°·54
M_2	R =	3·666	K_2	R =	·550	ν_2	R =	·286	$(M_2N)_4$	R =	·250
	ζ =	177°·60		ζ =	265°·49		ζ =	122°·11		ζ =	45°·00
	H =	3·743		H =	·465		H =	·292		H =	·261
	κ =	54°·68		κ =	91°·45		κ =	17°·38		κ =	19°·84
M_3	R =	·029	P_1	R =	·158	μ_2	R =	·242	$(M_2K_1)_3$	R =	·137
	ζ =	346°·31		ζ =	236°·63		ζ =	65°·08		ζ =	316°·94
	H =	·030		H =	·158		H =	·252		H =	·131
	κ =	341°·93		κ =	46°·62		κ =	179°·24		κ =	17°·29
M_4	R =	·737	J_1	R =	·018	R_2	R =	...	$(2M_2K_1)_3$	R =	·048
	ζ =	275°·56		ζ =	5°·68		ζ =	...		ζ =	29°·85
	H =	·768		H =	·017		H =	...		H =	·047
	κ =	29°·72		κ =	325°·46		κ =	...		κ =	320°·74

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide	·348	233°·36	·375	12°·68
„ Fortnightly „	·295	104°·37	·231	48°·22
Luni-Solar „ „	·872	278°·59	·890	41°·51
Solar-Annual „	2·762	236°·99	2·762	157°·00
„ Semi-Annual „	1·107	147°·26	1·107	347°·29

RANGOON, 1910.

Short Period Tides.

A_0=10·378 feet.

S_1	H = R =	·103	M_6	R =	·228	Q_1	R =	·027	T_2	R =	·237
	κ = ζ =	133°·98		ζ =	94°·48		ζ =	114°·31		ζ =	195°·35
S_2	H = R =	2·128		H =	·242		H =	·024		H =	·237
	κ = ζ =	167°·03		κ =	87°·31		κ =	32°·44		κ =	196°·75
S_4	H = R =	·082	M_8	R =	·104	L_2	R =	·407	$(MS)_4$	R =	·495
	κ = ζ =	256°·95		ζ =	227°·79		ζ =	310°·17		ζ =	332°·25
S_6	H = R =	·010		H =	·113		H =	·486		H =	·506
	κ = ζ =	70°·35		κ =	98°·24		κ =	127°·20		κ =	209°·86
S_8	H = R =	·003	O_1	R =	·312	N_2	R =	1·003	$(2SM)_2$	R =	·197
	κ = ζ =	113°·20		ζ =	324°·47		ζ =	22°·80		ζ =	287°·68
				H =	·279		H =	1·024		H =	·201
				κ =	21°·65		κ =	121°·38		κ =	50°·07
M_1	R =	·053	K_1	R =	·744	λ_2	R =	...	$2N_2$	R =	·287
	ζ =	75°·86		ζ =	209°·18		ζ =	...		ζ =	78°·02
	H =	·027		H =	·604		H =	...		H =	·293
	κ =	122°·75		κ =	32°·44		κ =	...		κ =	37°·55
M_2	R =	5·752	K_2	R =	·716	ν_2	R =	·385	$(M_2N)_4$	R =	·186
	ζ =	253°·37		ζ =	344°·09		ζ =	200°·88		ζ =	191°·35
	H =	5·873		H =	·606		H =	·394		H =	·194
	κ =	130°·98		κ =	170·°01		κ =	96°·93		κ =	167°·53
M_3	R =	·034	P_1	R =	·212	μ_2	R =	·508	$(M_2K_1)_3$	R =	·187
	ζ =	170°·68		ζ =	244°·31		ζ =	182°·02		ζ =	6°·39
	H =	·035		H =	·212		H =	·530		H =	·178
	κ =	167°·10		κ =	54°·31		κ =	297°·24		κ =	67°·25
M_4	R =	·539	J_1	R =	·033	R_2	R =	...	$(2M_2K_1)_3$	R =	·127
	ζ =	52°·60		ζ =	155°·73		ζ =	...		ζ =	119°·14
	H =	·562		H =	·029		H =	...		H =	·123
	κ =	167°·82		κ =	115°·21		κ =	...		κ =	51°·11

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide .	·183	238°·83	·197	17°·86
„ Fortnightly „	·173	98°·33	·136	41°·60
Luni-Solar „ „	·404	286°·80	·412	4[illegible]°·19
Solar-Annual „	1·285	231°·63	1·285	151°·63
„ Semi-Annual „	·262	153°·70	·262	353°·68

MOULMEIN, 1910.

Short Period Tides.

$A_0 = 8·623$ feet.

S_1	H = R =	·104	M_6	R =	·082	Q_1	R =	·034	T_2	R =	·145
	κ = ζ =	141°·37		ζ =	178°·60		ζ =	144°·54		ζ =	163°·34
S_2	H = R =	1·500		H =	·087		H =	·031		H =	·145
	κ = ζ =	142°·89		κ =	171°·73		κ =	62°·83		κ =	164°·74
S_4	H = R =	·087	M_8	R =	·053	L_2	R =	·336	$(MS)_4$	R =	·797
	κ = ζ =	209°·40		ζ =	227°·51		ζ =	297°·73		ζ =	319°·50
S_6	H = R =	·011		H =	·057		H =	·401		H =	·814
	κ = ζ =	188°·95		κ =	98°·35		κ =	114°·81		κ =	197°·21
S_8	H = R =	·003	O_1	R =	·246	N_2	R =	·728	$(2SM)_2$	R =	·150
	κ = ζ =	254°·93		ζ =	348°·54		ζ =	357°·44		ζ =	272°·79
				H =	·220		H =	·743		H =	·153
				κ =	45°·81		κ =	96°·17		κ =	35°·08
M_1	R =	·045	K_1	R =	·504	λ_2	R =	...	$2N_2$	R =	·173
	ζ =	92°·79		ζ =	210°·99		ζ =	...		ζ =	48°·32
	H =	·023		H =	·469		H =	...		H =	·176
	κ =	139°·74		κ =	34°·24		κ =	...		κ =	8°·06
M_2	R =	4·024	K_2	R =	·495	ν_2	R =	·269	$(M_2N)_4$	R =	·317
	ζ =	231°·61		ζ =	319°·68		ζ =	179°·89		ζ =	171°·04
	H =	4·109		H =	·419		H =	·275		H =	·330
	κ =	109°·32		κ =	145°·60		κ =	76°·08		κ =	147°·47
M_3	R =	·030	P_1	R =	·167	μ_2	R =	·384	$(M_3K_1)_3$	R =	·190
	ζ =	175°·53		ζ =	249°·45		ζ =	168°·63		ζ =	7°·75
	H =	·031		H =	·167		H =	·401		H =	·181
	κ =	172°·09		κ =	59°·46		κ =	279°·05		κ =	68°·71
M_4	R =	·914	J_1	R =	·014	R_2	R =	...	$(2M_2K_1)_3$	R =	·108
	ζ =	43°·32		ζ =	136°·77		ζ =	...		ζ =	124°·08
	H =	·953		H =	·012		H =	...		H =	·105
	κ =	158°·74		κ =	96°·19		κ =	...		κ =	56°·25

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tide . . .	·367	240°·23	·396	19°·22
„ Fortnightly „ . . .	·406	97°·97	·318	41°·13
Luni-Solar „ „ . . .	1·176	282°·37	1·201	44°·66
Solar-Annual „ . . .	2·286	232°·52	2·286	152°·51
„ Semi-Annual „ . . .	·561	120°·07	·561	320°·05

PORT BLAIR, 1910.

Short Period Tides.

A_0 = 4·877 feet.

S_1	$H = R =$	·025	M_6	$R =$	·003	Q_1	$R =$	·019	T_2	$R =$	·082
	$\kappa = \zeta =$	96°·16		$\zeta =$	61°·56		$\zeta =$	350°·89		$\zeta =$	340°·96
S_2	$H = R =$	·979		$H =$	·003		$H =$	·017		$H =$	·082
	$\kappa = \zeta =$	313°·83		$\kappa =$	53°·70		$\kappa =$	268°·66		$\kappa =$	342°·35
S_4	$H = R =$	·005	M_8	$R =$	·001	L_2	$R =$	·045	$(MS)_4$	$R =$	·014
	$\kappa = \zeta =$	195°·15		$\zeta =$	188°·13		$\zeta =$	96°·44		$\zeta =$	274°·18
S_6	$H = R =$	·003		$H =$	·001		$H =$	·054		$H =$	·015
	$\kappa = \zeta =$	353°·66		$\kappa =$	57°·65		$\kappa =$	273°·36		$\kappa =$	151°·56
S_8	$H = R =$	·001	O_1	$R =$	·173	N_2	$R =$	·381	$(2SM)_2$	$R =$	·014
	$\kappa = \zeta =$	355°·60		$\zeta =$	246°·40		$\zeta =$	178°·60		$\zeta =$	28°·07
				$H =$	·154		$H =$	·389		$H =$	·014
				$\kappa =$	303°·33		$\kappa =$	276°·82		$\kappa =$	150°·69
M_1	$R =$	·007	K_1	$R =$	·429	λ_2	$R =$	...	$2N_2$	$R =$	·046
	$\zeta =$	323°·75		$\zeta =$	142°·08		$\zeta =$	...		$\zeta =$	299°·35
	$H =$	·004		$H =$	·400		$H =$	...		$H =$	·047
	$\kappa =$	10°·53		$\kappa =$	325°·34		$\kappa =$	...		$\kappa =$	258°·41
M_2	$R =$	1·965	K_2	$R =$	·313	ν_2	$R =$	·119	$(M_2N)_4$	$R =$	·004
	$\zeta =$	41°·71		$\zeta =$	126°·13		$\zeta =$	340°·52		$\zeta =$	118°·74
	$H =$	2·006		$H =$	·265		$H =$	·121		$H =$	·004
	$\kappa =$	279°·09		$\kappa =$	312°·07		$\kappa =$	236°·22		$\kappa =$	94°·34
M_3	$R =$	·008	P_1	$R =$	·138	μ_2	$R =$	·070	$(M_2K_1)_3$	$R =$	·016
	$\zeta =$	20°·56		$\zeta =$	154°·95		$\zeta =$	166°·13		$\zeta =$	129°·18
	$H =$	·008		$H =$	·138		$H =$	·073		$H =$	·015
	$\kappa =$	16°·63		$\kappa =$	324°·95		$\kappa =$	280°·89		$\kappa =$	189°·83
M_4	$R =$	·020	J_1	$R =$	·020	R_2	$R =$	...	$(2M_2K_1)_3$	$R =$	·005
	$\zeta =$	349°·04		$\zeta =$	328°·99		$\zeta =$	...		$\zeta =$	296°·05
	$H =$	·021		$H =$	·018		$H =$	...		$H =$	·005
	$\kappa =$	103°·80		$\kappa =$	288°·60		$\kappa =$	...		$\kappa =$	227°·55

Long Period Tides.

	R	ζ	H	κ
Lunar Monthly Tido . .	·021	244°·83	·023	23° 99
„ Fortnightly „	·073	75°·01	·057	18°·53
Luni-Solar „ „ . . .	·028	311°·94	·029	74°·56
Solar-Annual „	·226	241°·07	·226	161°·08
„ Semi Annual „ . .	·042	333° 76	·042	173°·77

OTHER COMPUTATIONS.

The actual times and heights of high and low water for 1910 at 12 ports have been compared with the predicted values published in the tide-tables, and the results tabulated.

SALE OF TIDE-TABLES.

The amount realized on the sale of tide-tables during the year ending September 1911 is Rs. 2,550-9.

DATA FORWARDED TO ENGLAND.

The following data were supplied to the Director, National Physical Laboratory, Teddington, England:—

(*i*) Values of the tidal constants for the tide-tables for 1914, ready for use in the tide predicting machine.

(*ii*) Actual values during 1909 of every high and low water, measured in duplicate from the tidal diagrams at 9 stations, and of tide-pole observations taken during daylight at 3 stations, the latter under the supervision of the Port Officers, and supplied by them to this office.

(*iii*) Comparisons of the above with predicted values for 1909, the errors being tabulated in such form as to be of use in improving the predictions.

ERRORS IN PREDICTIONS.

The five tabular statements which are appended, show the percentage and amount of error in the predicted times and heights of high and low water for the year 1910 at 12 stations, as determined by comparisons of the predictions given in the tide-tables with the actual values measured from the tidal diagrams at 9 stations, and from the tide-poles at 3 stations; the former are made in this office, and the latter by the port officials concerned.

No. 1.

Statement showing the percentage and the amount of the errors in the predicted times of high water at the various Tidal Stations for the year 1910.

Stations.	Automatic or Tide-pole observations.	Number of comparisons between actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
			Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Aden	Auto.	670	36	44	10	7	3
Karāchi	Auto.	706	32	45	11	10	2
Bhāvnagar	T. P.	365	58	42	0	0	0
Bombay { Apollo Bandar	Auto.	704	35	46	9	8	2
Bombay { Prince's Dock	Auto.	696	36	44	9	8	3
Madras	Auto.	705	35	52	8	4	1
Kidderpore	Auto.	704	18	30	15	22	15
Chittagong	T. P.	359	26	26	9	19	20
Akyab	T. P.	364	98	2	0	0	0
Rangoon	Auto.	705	37	32	10	15	6
Moulmein	Auto.	701	21	32	14	18	15
Port Blair	Auto.	705	30	49	10	8	3

question; the remaining three are satisfactorily identified; they are respectively 813, 927 and 970 feet above Kāsāra and show discrepancies of 0·164, 0·186, 0·225 feet. The fairly good agreement of these three quantities *inter se*, and the progressive increase in the differences, do not point to accidental movements of the bench-marks; the evidence is rather that the marks have retained their positions, but that there is a systematic difference between the old and the new levelling. The appearance of the discrepancies leads one to suspect an error in staff length, and if this be accepted as the cause, preference must be given to the modern work, as much greater attention is now given to the comparisons of the staves with the standard than formerly. Furthermore, since the error of the height of any point, due to this cause, will be directly proportional to the elevation above sea-level, the error at Kāsāra will be less than that at Igatpuri, and the heights of the new rock-cut bench-marks have therefore been deduced from the old value of that of Kāsāra, though the line was actually run from Igatpuri.

Line Marmagao to Belgaum.—The line Marmagao to Belgaum closes a levelled circuit, *viz.*, Marmagao, Belgaum, Hubli, Kārwār, Marmagao; all the parts of which, except the line Kārwār-Marmagao (1886-87), have been connected or revised recently. The length of the circuit is 322 miles, and the closing error, using the observed differences of level throughout, is 0·308 of a foot, as shown below:

Lines	Distance in miles.	Observed difference of elevation in feet.	Date.
From G. T. S. O B. M. At Tidal observatory Marmagao to G. T. S. O B. M. at Railway Station Belgaum.	102·1	+ 2439·024	1910-11
From G. T. S. O B. M. At Railway Station Belgaum to G. T. S. □ B. M. at Hubli.	60·3	− 394·722	1910-11
From G. T. S. □ B. M. At Hubli to G. T. S. □ B. M. at Kārwār.	102·7	− 2048·893	1907-08
From G. T. S. □ B. M. At Kārwār to G. T. S. O B. M. at Tidal Observatory Marmagao.	56·7	+ 4·283	1886-87
	321·8	− 0·308	...

Until however the dynamic or the orthometric heights of the stations have been deduced, no conclusion can be drawn from this apparent closing error, for an errorless circuit of observed differences of level will not in general close.

The orthometric heights of the Marmagao and Belgaum bench-marks, given in G. T., Volume XIXA, differ by 2507·565 feet; applying an approxi-

mately computed correction to the difference of level between these bench-marks as now observed, we obtain 2507·190 as the difference between their orthometric heights, showing a discrepancy of —0·375 between the old and the new values. The length of the new line Marmagao-Belgaum is 102 miles, so that, if the old values which are the result of the simultaneous reduction are considered errorless, an error of 0·0037 per mile has been generated in this new work.

Revision of line Belgaum to Hubli.—The result of the revisionary levelling from Belgaum to Hubli is also given in Table I. It was decided to have this portion of the line revised, as the revisionary levelling of the line Kārwār to Hubli had shown a big discrepancy, *viz.*, 0·68 of a foot, between the old and new values of two bench-marks, one at Hubli and one 40 miles therefrom (*vide* page 335, G. T., Vol. XIX). The present levelling shows satisfactory accordance with the 1878 work, and proves that the embedded bench-mark at Hubli has not been disturbed since its original connection in that year.

The revision of the line Belgaum-Hubli also assists in settling the controversy which arose between the levelling officers and the Computing Office about the connection between the levelling of 1873-74 and that of 1907-08 (*vide* para. 12, page 335, G. T., Vol. XIX.)

The present levelling shows that the arrow B. M. * at Hubli is 2·390 feet above the embedded bench-mark † fixed in 1878; in that year this difference was found to be 2·365, but the stone on which the arrow is cut is neither smooth nor level, and the exact spot on which the staff should be held is not defined, so this agreement is as good as could be expected.

Referring to the records of 1873-74 we find that the arrow B. M. was 2061·18 feet above mean sea-level. The operations of 1878-79 made this height 2062·34, and the present levelling gives 2062·53. These values are all unadjusted observed values, not orthometric heights. The evidence is now conclusive that the arrow B. M. suffered displacement between 1873 and 1878, and that there is no link between the work of 1873-74 and that of 1907-08.

No. 2. Levelling Detachment.

This detachment had for its programme —

(1) To level from Gauhāti to Dibrugarh.

(2) To connect the standard bench-marks at Dhubri, Gauhāti and Dibrugarh.

(3) To commence a line of levels from Gauhati to Chittagong.

PERSONNEL.

Provincial Officers.

Mr. O. N. Pushong.
Mr. D. H. Luxa, until 1st March 1911.

Upper Subordinate Service.

Mr. K. K. Das.

Lower Subordinate Service.

3 Recorders.

This season 2 bench-marks of the embedded type which were laid down were moulded of stone cement concrete. The lettering on these bench-marks, in order to make them conform to the usual design, was done by the detachment, and the material appeared unusually soft under the chisel. It remains to be seen whether bench-marks so composed are as durable as those made of stone.

* $\frac{a}{234}$ of line 29.

† 235 of line 29.

No. 3. Levelling Detachment.

The following programme of work was allotted to the detachment :—

PERSONNEL.

Provincial Officers.

Mr. A. M. Talati.
Mr. O. D. Jackson.

Lower Subordinate Service.

3 Recorders.

(*i*) Levelling from Ambāla, along the Delhi-Ambāla-Kālka Railway, to Kālka and thence along the Simla road to Solon.

(*ii*) Levelling from Dera Ismail Khān along the Bannu road to Chunda, at foot of the Marut range.

(*iii*) Levelling from Daryā Khān to Rāwalpindi along the Kacha road *viá* Jandanwāla, Khushāb, Kathwai, Jaba and Talagang, with a branch line from Khushāb to Shāhpur, crossing the Jhelum.

(*iv*) Levelling from Nowshera to Rishalpur Cantonment along the Mardān road.

(*v*) Levelling from Rāwalpindi to Murree along the Kashmīr road.

The seven proposed lines of precise levelling to connect the Himālayan range with the main lines of levels have all been completed, now that the connections of Ambāla to Solon and Rāwalpindi to Murree have been made. The line from Dera Ismail Khān to Chunda connects the rocky range west of the Indus to the main lines of levels, as well as to the Himālayan range direct, *viá* Daryā Khān and Rāwalpindi.

The line Daryā Khān to Rāwalpindi *viá* Khushāb breaks up the large circuit Murghai-Chach-Lahore-Ferozepore-Murghai (parts of which were worked as early as in 1859) into two parts, namely, Daryā Khān Chach-Rāwalpindi Daryā Khān and Daryā Khān Rāwalpindi Lahore Ferozepore-Murghai Daryā Khān ; the second of these will be further broken up into three smaller circuits next field season.

Closing error.—The height of Rāwalpindi above Daryā Khān deduced from the corrected orthometric heights given in G. T., Volume XIXB, is +1101·582 feet; the observed value of this height given by the new line of levelling is +1101·817 feet; this reduced to orthometric terms is approximately 1101·772. Thus showing a discrepancy of 0·190 foot in 212 miles. As the heights of all bench-marks connected up to 1909 have been adjusted and published in Volumes XIXA and XIXB, this discrepancy will, for the present, be dispersed between Daryā Khān and Rāwalpindi.

Table I shows the discrepancies between the old and new heights of the bench-marks of the original levelling which were connected this season. The check-levelling at Ambāla shows a certain peculiarity ; all the bench-marks at the railway station and at the Royal Horse Artillery lines agree well together, but show a discrepancy with the standard, while the latter agrees well with the two bench-marks at the Church. This will be investigated by a re-check levelling of all these bench-marks, when an opportunity occurs.

TABLE I.—No. 1 DETACHMENT.

Discrepancies between the old and new values of bench-marks.

Description of bench-marks of the original levelling that were connected for check levelling.	Distance from starting bench-marks.	Observed height above (+) or below (—) starting bench-mark as determined by: Original levelling.	Check levelling, 1910-11.	Difference (Check—Original). The sign + denotes that the height was greater and the sign — less in 1910-11, than when originally levelled.	Remarks.
	Miles.	Feet.	Feet.	Feet.	
Check levelling between Igatpuri-Kāsāra, part of main line 33 (Kalyān to Nandgaon), 1877-78.					
G. T. S. □ B. M. At Kāsāra Ry. Station	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At Dharamsala, Kāsāra	0·3	—9·528	—9·551	—0·023	
G. T. S. O B. M. At bridge No. 275, at mile 75, Bombay-Nāsik Road.	1·2	—185·532	—185·551	—0·019	
G. T. S. O B. M. At drain No. 278 near furlong stone No. 75/2 Bombay	1·4	—124·252	—124·262	—0·010	
G. T. S. O B. M. At bridge No. 290, 1 furlong south of mile plate No. 76, Bombay-Nāsik Road.	*2·2	+22·640	+22·654	+0·014	*Seemed to be identical with B.M. No. 50 shown as destroyed in levelling, Volume XIXA.
G. T. S. O B. M. At parapet wall 2 chs. south of mile 79 Bombay.	†5·2	+163·857	+163·790	—0·067	† Same remark as above, but identical with No. 52
G. T. S. O B. M. At drain No. 318 near furlong post 79/4, Bombay.	‡5·7	+290·354	+290·280	—0·074	‡ Same remark as above, but identical with No. 53.
G. T. S. O B. M. At Toll House, mile 79/6 Bombay.	§6·0	+361·439	+361·475	+0·036	§ Same remark as above, but identical with No. 54.
O B. M. At drain No. 184	‖6·3	+416·312	+416·358	+0·046	‖ Same remarks as above, but identical with No. 55.
B. O. M. At drain No. 27, 37 chs. west of mile 83, Bombay.	8·8	+813·195	+813·259	+0·164	
O B. M. At bridge No. 30	9·6	+927·599	+927·785	+0·186	
G. T. S. □ B. M. At Igatpuri Railway Station	12·0	+969·861	+970·086	+0·225	
Check levelling between Karjat-Palasdhari, part of main line 31 (Kalyān to Kedgaon), 1906-07.					
G. T. S. □ B. M. At Karjat Ry. Station	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At bridge near Telegraph post No. 61/4.	0·9	—9·247	—9·219	+0·028	
G. T. S. O B. M. At Palasdhari Ry. Station	1·7	+35·046	+35·056	+0·010	
Check-levelling at Khopoli, part of main line 31 (Kalyān to Kedgaon), 1906-07.					
G. T. S. □ B. M. At Khopoli Ry. Station	0·0	0·000	0·000	0·000	

TABLE I—No. 1 DETACHMENT—*continued.*

Discrepancies between the old and new values of bench-marks – contd.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) STARTING BENCH-MARK AS DETERMINED BY: Original levelling.	OBSERVED HEIGHT ABOVE (+) OR BELOW (—) STARTING BENCH-MARK AS DETERMINED BY: Check levelling, 1910-11.	Difference (Check—Original). The sign + denotes that the height was greater and the sign — less in 1910-11, than when originally levelled.	REMARKS.
	Miles.	Feet.	Feet.	Feet	
G. T. S. O B. M. At Goods platform, Khopoli Ry. Station.	0·1	+3·073	+3·069	—0·004	
G. T. S. O B. M. At bridge, 17 chs. north of Khopoli Ry. Station.	0·3	—2·106	—2·113	—0·007	
Check-levelling between Khandāla-Lonavla, part of main line 31 (Kalyān to Kedgaon), 1906-07.					
G. T. S. O B. M. At Parsi Dharamsala Khandāla.	0·0	0·000	0·000	0·000	
G. T. S. □ B. M. At Khandāla Ry. Station .	0·6	+17·494	+17·472	—0·022	
Check-levelling between Poona and Kirkee, part of main line 31 (Kalyān to Kedgaon), 1906-07.					
G. T. S. Standard Bench-mark at Assistant Commanding Royal Engineer's office, Poona.	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At reservoir of old water works tower near Arsenal, Poona.	0·1	+14·997	+14·990	—0·007	
G. T. S. Standard Bench-mark at All Saints' Church, Kirkee.	5·0	—12·518	—12·510	+0·008	
Check-levelling at Marmagao Branch line 17A (Kārwār-Marmagao), 1886-87.					
G. T. S. O B.M. At Marmagao Tidal Observatory.	0·0	0·000	0·000	0·000	
G. T. S. □ B. M. Ditto ditto .	0·1	— 3·537	— 3·719	— 0·182	
G. T. S. O B. M. At platform coping opposite Booking Office, Vasco-da-Gama Railway Station.	1·5	+ 0·810	+ 0·715	— 0·095	Probably sunk.
G. T. S. B. O. M. At masonry plinth, Vasco-da-Gama Railway Station.	1·4	+ 0·045	— 0·023	— 0·068	
G. T. S. B. O. M. At railway bridge, ½ mile east of Vasco-da-Gama Railway Station.	1·9	+ 5·769	+ 5·689	— 0·080	
G. T. S. O B. M. At bridge No. 4, 1·9 miles east of Vasco-da-Gama Railway Station.	3·3	+79·870	+79·883	+ 0·013	
G. T. S. B. O. M. At drain 12 chs. east of mile 7 Marmagao.*	6·4	+38·822	+38·816	— 0·006	* Seems to be identical with B. M. 35 of branch line 17-A.
O. G. T. S. B. M. At bridge 10 chs. east of Cansaulim Railway Station.	9·5	+16·745	+16·735	— 0·010	

TABLE I.—No. 1 DETACHMENT—*continued.*

Discrepancies between the old and new values of bench-marks—contd.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by		Difference (Check—Original). The sign + denotes that the height was greater and the sign — less in 1910-11 than when originally levelled.	Remarks.
		Original levelling.	Check-levelling, 1910-11.		
	Miles.	Feet.	Feet.	Feet.	
G. T. S. B. O. M. At bridge near telegraph post No. $\frac{11}{10}$.	10·7	+22·103	+22·101	— 0·002	
G. T. S. B. O. M. At bridge near telegraph post No. $\frac{12}{9}$†	11·6	+18·347	+18·339	— 0·008	† Seems to be identical with No. 31 of branch line 17-A.
G. T. S. O B. M. At bridge between telegraph posts Nos. $\frac{15}{8}$ and $\frac{16}{9}$.	15·1	— 0·700	— 0·725	— 0·025	
G. T. S. □ B. M. At Margao Railway station	16·1	+11·956	+11·937	— 0·019	
G. T. S. □ B. M. At Navelim . . .	17·1	+ 9·636	+ 9·608	— 0·024	
G. T. S. □ B.M. At Margao-Masan (Hindu burning place.)	16·7	+54·368	+54·367	— 0·001	
G. T. S. O B. M. On platform coping opposite booking office, Margao Railway Station.	16·2	+11·500	+11·484	— 0·016	
G. T. S. O B. M. At plinth of iron column, Margao Railway Station.	16·3	+10·511	+10·500	— 0·011	
Check-levelling at Belgaum main line 29 (Nira to Hubli), connection of standard bench-mark, 1908-09.					
G. T. S. O B. M. At Belgaum Railway Station.	0·0	0·000	0·000	0·000	
G. T. S. Standard Bench-mark, Belgaum.	0·7	+68·212	+68·215	+ 0·003	
G. T. S. O B. M. At Post Office, Belgaum .	0·3	—5·117	— 5·119	— 0·002	
B. ⊕ M. At Bhimrao Patel's House in Bazar, Belgaum	0·6	—5·971	— 5·985	— 0·014	
G. T. S. O B. M. At drain at junction of Fort and Station road with Dhārwār-Belgaum Road.	1·0	—8·485	— 8·488	—0·003	
G. T. S. O B. M. At drain at junction of Fort and Station road with that to Race-course.	1·2	—1·713	— 1·715	— 0·002	
G. T. S. □ B. M. At Belgaum.	1·6	+18·341	+18·382	+ 0·041	

TABLE I.—No. 1 DETACHMENT—*concluded.*

Discrepancies between the old and new values of bench-marks—concld.

Description of bench-marks of the original levelling that were connected during the revisionary operations.	Number in Vol. XIX-A.	Distance from starting point.	Observed height above (+) or below (—) starting point as determined in 1877-78-79.	Observed height above (+) or below (—) starting point as determined in 1910-11.	Difference (Revised—Original). The + sign denotes that the height was greater and the — sign less in 1910-11, than it was when originally levelled.	Remarks.
		Miles.	Feet.	Feet.	Feet.	
Revision line No. 20—Belgaum-Hubli.						
G. T. S. □ B. M. At Belgaum	212	0·0	0·000	0·000	0·000	
G. T. S. O B. M. At bridge 251 near F. S. $\frac{225}{7}$	215	12·2	—263·361	—263·388	—0·027	
G. T. S. □ B. M. At Bāgevādi	216	12·2	—272·010	—272·045	—0·035	
G. T. S. □ B. M. At Mugat-Khān Hubli	217	17·0	—309·088	—309·157	—0·069	
B. O. M. At bridge 272 between F. S. Nos. $\frac{231}{3 \text{ and } 4}$.	218	17·8	—367·231	—367·317	—0·086	
B. O. M. At bridge 273, 4 chs. north of mile 18, Belgaum.	219	18·3	—388·250	—388·598	—0·348*	* Probably disturbed.
G. T. S. □ B. M. At Hulikati	221	23·5	—214·483	—214·594	—0·111	
Culvert No. 306 near mile 25, Belgaum.	222	25·4	—134·757	—134·777	—0·020	
Culvert No. 323 between F. S. Nos. $\frac{241}{2 \text{ and } 3}$.	223	27·9	— 92·006	— 92·012	—0·006	
G. T. S. □ B. M. At Kittur	224	28·2	— 61·438	— 61·638	—0·200†	† Probably sunk.
G. T. S. □ B. M. At Tegur	226	34·0	— 96·065	— 96·128	—0·063	
Culvert No. 33, 1½ chs. north-west of F. S. $\frac{253}{1}$.	228	39·7	—201·565	—201·581	—0·016	
G. T. S. □ B. M. At Mumigata	229	41·9	—171·507	—171·519	—0·012	
G. T. S. □ B. M. Dhārwār	231	47·1	— 88·186	— 88·127	+0·059	
G. T. S. □ B. M. Rayapur	232	53·5	—170·963	—170·939	+0·024	
↑ O B. M. At Hubli Travellers' Bungalow.	$\frac{a}{234}$	60·0	—410·699	—410·714	—0·015	
G. T. S. □ B M. At Hubli	235	60·0	—413·064	—413·104	—0·040	

The larger difference between the levellers on the Belgaum-Bāgalkot line is attributable to the unfavourable atmosphere conditions which prevailed when this line was run. The weather was hot and the readings of the staves were at times rendered uncertain by the boiling of the air, even though the lengths of the shots were reduced.

TABLE I.—No. 2 DETACHMENT.

Discrepancies between the old and new values of bench-marks.

	Description of bench-marks of the original levelling that were reconnected for check-levelling.	Number in Vol. XIXB.	Distance from starting point.			OBSERVED HEIGHT ABOVE (+) OR BELOW (—) STARTING POINT AS DETERMINED BY		Difference (Check—Original). The + sign denotes that the height was greater and the — sign less in 1910-11 than it was when originally levelled.	REMARKS.
			Mls.	Chs.	Lks.	Original levelling.	Check-levelling.		
	Branch Line No. 77A (Pārvatīpur to Gauhāti).								
1895	At Gauhāti Railway Station .	$\frac{a}{73}$	...			...	...	...	* This bench-mark was *built* as the levelling approached Gauhāti and the connection was effected soon after. The Officer in charge of this piece of levelling stated, before the check-levelling of season 1910-11 was taken up, that the B. M. would be found to have *sunk*, more especially as it was *on* the platform of the Railway Station. The check-levelling indicates that it has sunk slightly.
* G.T.S. □ B.M.	At „ „ „ .	74	0	6	76	— 0·423	— 0·452	—0·029	
	At culvert near T. P. No. $\frac{2}{11}$.	72	2	9	16	— 3·593	— 3·608	—0·015	† No mark was originally inscribed so that the point of reference is uncertain and the comparison therefore of little value. The surface of culvert is very rough and not very suitable for a bench-mark, so no letters were added.
† G.T.S. □ B.M.	At Khanamukh . . .	$\frac{b}{70}$	7	74	0	—11·556	—11·571	—0·015	
	Check-levelling at Dhubri.								
G.T.S. O B.M.	At Dhubri Post Office . .	44	...			...	...	...	
G.T.S. ⊕ B.M.	Near Government Ganja Shop	$\frac{1}{44}$	0	41	54	—17·687	—17·677	+0·010	
G.T.S. ⊕ B.M.	Opposite Police Lines, Dhubri .	$\frac{2}{44}$	0	62	0	—18·822	—18·820	+0·002	

TABLE I.—No. 3 DETACHMENT.

Discrepancies between the old and new values of bench-marks.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (−) starting bench-mark as determined by Original levelling.	Observed height above (+) or below (−) starting bench-mark as determined by Check-levelling, 1910-11.	Difference (Check—Original). The sign + denotes that the height was greater and the sign— less in 1910-11 than it was when originally levelled.	REMARKS.
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Ambāla—Main Line 61 (Ferozepore to Meerut), 1906-07.					
Standard Bench-mark at St. Paul's Church.	0·0	0·000	0·000	...	
+ at Memorial St. Paul's Church	0·1	—1·326	—1·312	+0·014	
901·6 /\ at St. Paul's Church	0·1	—1·829	—1·827	+0·002	
G. T. S. O B. M. At N. W. end of B. platform of Ambāla Cantonment Railway Station.	1·3	—4·496	—4·447	+0·049	
G. T. S. O B. M. At A. platform of Ambāla Cantonment Railway Station.	1·5	—5·361	—5·325	+0·036	
G. T. S. O B. M. At Wesleyan Church	0·9	+1·875	+1·913	+0·038	
G. T. S. O B. M. At block No. 3, Section Hospital.	1·1	+3·140	+3·182	+0·042	
G. T. S. O B. M. At block No. 2, Section Hospital.	1·1	+2·274	+2·312	+0·038	
G. T. S. O B. M. At block 42, Royal Horse Artillery Lines.	1·8	+8·261	+8·296	+0·035	
G. T. S. O B. M. At block 43, Royal Horse Artillery Lines.	1·9	+9·655	+9·671	+0·016	
Check-levelling at Dera Ismail Khān—Main Line 55 (Murghai to Chach), 1906-07-08					
Standard Bench-mark at Dera Ismail Khān.	0·0	0·000	0·000	...	
592·40 574·52 At St. Thomas Church	0·2	+0·179	+0·203	+0·024	
G. T. S. □ B. M. Embedded at St. Thomas Church.	0·1	—1·888	—1·864	+0·024	
+ At Tomb, St. Thomas Church	0·2	—0·219	—0·206	+0·013	
G. T. S. O B. M. At Brigade Office	0·4	—1·927	—1·930	—0·003	
G. T. S. O B. M. At A. C. R. E.'s Office	0·8	—2·939	—2·928	+0·011	
G. T. S. O B. M. At District Local Board's Office.	0·9	—0·428	—0·436	—0·008	
□ /\ At mile-stone No. 1	0·2	+1·339	+1·395	+0·056*	* This bench-mark appears to have been disturbed and the new value should now be accepted.

TABLE I.—No. 3 DETACHMENT—*concld.*

Discrepancies between the old and new values of bench-marks—concld.

Description of bench-marks of the original levelling that were connected for check-levelling.	Distance from starting bench-mark.	Observed height above (+) or below (—) starting bench-mark as determined by		Difference (Check—Original). The sign + denotes that the height was greater and the sign — less in 1910-11 than it was when originally levelled.	Remarks.
		Original levelling.	Check-levelling, 1910-11.		
	Miles.	Feet.	Feet.	Feet.	
Check-levelling at Daryā Khān—Main Line 55 (Murghai to Chach).					
G. T. S. O B. M. At south end of platform of Daryā Khān Railway Station.	0·0	0·000	0·000	...	
G. T. S. O B. M. At north end of platform of Daryā Khān Railway Station.	0·1	+0·294	+0·297	+0·003	
Check-levelling at Rāwalpindi—Main Line 56 (Ferozepore to Chach), 1905-06.					
Standard Bench-mark at Rāwalpindi	0·0	0·000	0·000	...	
G. T. S. O B. M. At Christ Church	0·0	—1·321	—1·322	—0·001	
G. T. S. O B. M. At Government Telegraph Office.	0·7	—17·109	—17·117	—0·008	
G. T. S. O B. M. At Lockhart Memorial	1·1	—24·038	—24·027	+0·011	
G. T. S. O B. M. At District Traffic Superintendent's Office.	1·6	—35·496	—35·492	+0·004	
G. T. S. □ B. M. Embedded at Rāwalpindi Railway Station.	1·6	—36·340	—36·346	—0·006	
G. T. S. O B. M. At platform of Rāwalpindi Railway Station.	1·8	—34·241	—34·237	+0·004	
G. T. S. O B. M. At platform opposite north-east corner of Rāwalpindi Railway Station.	1·8	—34·227	—34·220	+0·007	
G. T. S. O B. M. At Leh railway bridge	2·9	—48·821	—48·813	+0·008	
Check-levelling at Nowshera Branch Line 56A (Chach to Peshāwar), 1906-07.					
G. T. S. O B. M. At bridge No. 275 (B. M. 17)	0·0	0·000	0·000	...	
G. T. S. □ B. M. Embedded at Nowshera Railway Station (B. M. 18).	0·8	—29·315	—29·314	+0·001	
G. T. S. O B. M. At east end of platform (B. M. 19).	0·9	—26·148	—26·143	+0·005	
G. T. S. O B. M. At west end of platform (B. M. 20).	1·1	—26·264	—26·269	—0·005	
G. T. S. O B. M. At bridge No. 280 (B. M. 21)	1·8	—19·333	—19·323	+0·010	

TABLE II.—No. 1 DETACHMENT.

Results of comparison of staves, season 1910-11.

Place and date of comparison.	Length of staff = 10ft. + Quantity below.				Remarks.
	Staff No. 05.	Staff No. 00.	Staff No. 01.	Staff No. 03.	
	Feet.	Feet.	Feet.	Feet.	
Igatpuri, 5th November 1910	−0·00003	−0·00210	−0·00363	−0·00468	Clear and dry.
Khardi, 15th „ 1910	+0·00062	−0·00113	−0·00292	−0·00401	Rain since last comparison.
Khandāla, 24th „ 1910	+0·00003	−0·00257	−0·00417	−0·00457	Clear and dry.
Poona, 1st December 1910	−0·00038	−0·00310	−0·00454	−0·00538	Clear.
Shikarpur, 10th „ 1910	−0·00040	−0·00311	−0·00461	−0·00560	Clear and dry.
Narāyangaon, 21st „ 1910	−0·00155	−0·00437	−0·00604	−0·00713	Ditto.
Tās, 29th „ 1910	−0·00078	−0·00392	−0·00454	−0·00651	Ditto.
Vasco-da-Gama, 12th January 1911.	−0·00003	−0·00355	−0·00389	−0·00521	Light scattered clouds, sudden gust of cool breeze.
Sanvordem, 21st January 1911.	+0·00060	−0·00264	−0·00335	−0·00478	Scattered clouds; country fairly damp.
Collem, 29th January 1911 .	+0·00030	−0·00284	−0·00395	−0·00483	Mist and clouds some mornings, otherwise clear.
Castle Rock, 9th February 1911.	−0·00008	−0·00359	−0·00420	−0·00494	Clear and dry.
Gunji, 18th February 1911	−0·00084	−0·00444	−0·00484	−0·00615	Scattered clouds one evening, otherwise clear.
Desur, 2nd March 1911	−0·00196	−0·00521	−0·00612	−0·00692	Clear and dry.
Belgaum, 11th „ 1911	−0·00187	−0·00539	−0·00684	−0·00784	Strong cool breeze afternoons, generally dusty.
Hulikati, 22nd „ 1911	−0·00246	−0·00589	−0·00679	−0·00884	Scattered clouds, hot and dry.
Dhārwār, 31st „ 1911	−0·00171	−0·00563	−0·00626	−0·00780	Scattered clouds, cool and dry.
Belgaum, 10th April 1911	−0·00172	−0·00568	−0·00589	−0·00777	Strong cool gusty breeze.
Halki, 19th „ 1911	−0·00223	−0·00541	−0·00631	−0·00821	Scattered clouds and cool breeze.
Budnur, 29th „ 1911	−0·00267	−0·00749	−0·00718	−0·00899	Scattered clouds and cool breeze; rain overnight once.
Kalādgi, 10th May 1911	−0·00228	−0·00744	−0·00732	−0·00885	Cloudy, hot and dry.
Bāgalkot, 15th „ 1911	−0·00291	−0·00835	−0·00833	−0·00942	A few drops of rain overnight on two or three occasions; sudden gusts of wind; scattered clouds.

TABLE II.—No. 2 DETACHMENT.

Result of comparison of staves, season 1910-1911.

Place and date of comparison.	Length of staff—10 ft. + Quantity below.				Remarks.
	Staff No. 20A.	Staff No. 20B.	Staff No. 16A.	Staff No. 16B.	
	Feet.	Feet.	Feet.	Feet.	
Dhubri, 1st November 1910	−0·00015	+0·00011	−0·00137	+0·00060	Clear and cool.
Gauhāti, 9th „ 1910	− ·00003	+ ·00097	− ·00010	+ ·00103	„ „ dry.
Sonapur, 19th „ 1910	+ ·00027	+ ·00102	− ·00017	+ ·00122	Light clouds and dry.
Nakhola, 1st December 1910	+ ·00138	+ ·00164	+ ·00047	+ ·00228	„ scattered clouds ; cool.
Raha, 9th „ 1910	+ ·00047	+ ·00125	+ ·00011	+ ·00105	Scattered clouds.
Samaguri, 20th „ 1910	+ ·00049	+ ·00098	− ·00006	+ ·00128	Clear.
Amguri, 2nd January 1911	+ ·00021	+ ·00066	− ·00026	+ ·00111	Clear and dry.
Kajiranga, 12th „ 1911	− ·00026	+ ·00079	− ·00027	+ ·00052	Light scattered clouds.
Dergaon, 24th „ 1911	+ ·00057	+ ·00153	+ ·00042	+ ·00143	Cloudy and cool.
Kakojan, 3rd February 1911	− ·00007	+ ·00110	− ·00009	+ ·00123	Light scattered clouds and cool.
Sibsāgar, 14th „ 1911	+ ·00028	+ ·00102	+ ·00021	+ ·00108	Scattered clouds and cool breeze.
Lepetkata, 24th „ 1911	+ ·00113	+ ·00225	+ ·00101	+ ·00182	Cloudy.
Dibrugarh, 1st March 1911	+ ·00086	+ ·00158	+ ·00075	+ ·00152	Light scattered clouds.
Bornihat, 23rd „ 1911	− ·00010	+ ·00062	− ·00045	+ ·00056	Clear cool breeze.
Nongpoh, 1st April 1911	− ·00019	+ ·00019	− ·00060	+ ·00052	Scattered clouds.
Umran, 11th „ 1911	− ·00027	+ ·00032	− ·00057	− ·00007	„ „
Shillong, 21st „ 1911	+ ·00116	+ ·00140	+ ·00137	+ ·00161	Cloudy.
Dumpep, 6th May 1911	+ ·00078	+ ·00175	+ ·00046	+ ·00177	Scattered clouds.

TABLE II.—No. 3 DETACHMENT.

Result of comparison of staves, season 1910-11.

Date and place of comparison.		LENGTH OF STAFF = 10 FT. + QUANTITY BELOW.				REMARKS.
		Staff No. 19A.	Staff No. 19B.	Staff No. 24A.	Staff No. 24B.	
		Feet.	Feet.	Feet.	Feet.	
Ambāla Cant.	28th Oct. 1910	+0·00080	+0·00060	—0·00279	—0·00137	Clear dewy mornings.
Lalru	6th Nov. 1910	+0·00083	+0·00058	—0·00327	—0·00207	Ditto.
Ghaggar	14th Nov. 1910	+0·00032	—0·00016	—0·00420	—0·00290	Light clouds mornings.
Kālka	21st Nov. 1910	—0·00059	—0·00069	—0·00524	—0·00330	Clear mornings.
Jabli	28th Nov. 1910	—0·00102	—0·00083	—0·00587	—0·00455	Ditto.
Dharmpur	6th Dec. 1910	—0·00176	—0·00180	—0·00647	—0·00149	Ditto.
Solon	13th Dec. 1910	—0·00210	—0·00209	—0·00701	—0·00500	Light clouds, very cold mornings.
Dera Ismail Khān.	23rd Dec. 1910	—0·00152	—0·00196	—0·00683	—0·00552	Ditto.
Yarik	31st Dec. 1910	—0·00191	—0·00174	—0·00676	—0·00505	Ditto.
Daryā Khān	11th Jan. 1911	—0·00122	—0·00158	—0·00527	—0·00362	Three showers of rain.
Hetu	19th Jan. 1911	—0·00042	—0·00043	—0·00461	—0·00317	Cloudy, rain once.
Jandanwāla	25th Jan. 1911	—0·00046	—0·00046	—0·00457	—0·00347	Ditto twice.
Punjab	3rd Feb. 1911	—0·00053	—0·00063	—0·00478	- 0·00356	Rain and sleet once, frost every morning.
Khushāb	10th Feb. 1911	—0·00105	—0·00125	—0·00515	—0·00384	Scattered clouds.
Khushāb	17th Feb. 1911	—0·00095	—0·00089	—0·00479	—0·00369	Ditto.
Kathwai	24th Feb. 1911	—0·00153	—0·00158	—0·00662	—0·00529	Ditto, rain once.
Sodhi	3rd Mar. 1911	—0·00145	—0·00165	—0·00636	—0·00528	Cloudy.
Jaba	11th Mar. 1911	—0·00071	—0·00073	—0·00521	—0·00401	Do., rain once.
Jatta	20th Mar. 1911	—0·00034	—0·00065	—0·00454	—0·00355	Drizzling and rain whole week.
Talagang	26th Mar. 1911	—0·00111	—0·00090	—0·00534	—0·00383	Light clouds.
Dulla	3rd Apl. 1911	—0·00046	—0·00073	—0·00491	—0·00369	Cloudy, rain thrice.
Chakri	10th Apl. 1911	—0·00052	—0·00110	—0·00560	—0·00397	Light clouds.
Chahan	18th Apl. 1911	—0·00037	—0·00105	—0·00597	—0·00415	Ditto.
Rāwalpindi	27th Apl. 1911	—0·00092	—0·00117	—0·00643	—9·00494	Ditto.
Rāwalpindi	5th May 1911	—0·00165	—0·00187	—0·00664	—0·00504	Cloudy.
Tret	12th May 1911	—0·00195	—0·00208	—0·00736	—0·00607	Scattered clouds.
Ghora Gali	16th May 1911	—0·00236	—0·00236	—0·00764	—0·00619	Clear.
Murree	21st May 1911	—0·00285	—0·00283	—0·00796	—0·00635	Do.

TABLE III.—No. 1 Detachment.

Tabular Statement of Out-turn of work, season 1910-11.

Section.	Month.	Number of miles of double levelling.			Total number of feet.		Number of stations at which instrument was set up.	Number of bench-marks connected.											Remarks.
								Primary.			Secondary.								
											Old.								
		Line.	Extras and Auxiliary.	Total.	Rises.	Falls.		Rock-cut protected.	Standard.	Principal stations of Triangulation.	Inscribed.	Embedded.	Embedded.	Inscribed.	Rock-cut.	Secondary station of triangulation.	Railway.	P. W. D.	
		mls. chs. lks.	mls. chs. lks.	mls. chs. lks.															
Kāsāra-Igatpuri	November 1910	11 78 94	0 46 28	12 45 22	1329·499	359·362	297	3	...	...	2	10	...	..	9	...	...	...	Connection of supplementary rock-cut bench-marks on the Bor and Thul Ghats and at Bombay.
Kāsāra-Khardi	November 1910	8 29 96	0 25 72	8 55 68	62·461	262·136	103	1	...	...	...	...	...	3	1	...	3	...	
Apollo Bandar-Colāba	November 1910	2 47 12	0 01 46	2 48 58	44·567	24·720	13	1	..	...	...	1	...	...	...	1*old	...	...	
Karjat-Palasdhari	November 1910	2 51 12	0 05 53	2 56 64	42·810	16·995	13	1	...	...	1	2	...	...	...	...	...	...	
Khopoli	November 1910	0 51 54	0 01 16	0 52 70	60·923	5·316	17	1	...	...	1	2	...	...	1	...	...	...	
Kalyān Sett's well	November 1910	0 07 44	...	0 07 44	42·037	...	6	...	...	...	...	1	...	...	1	...	...	...	
Khandāla-Lonāvla	November 1910	3 04 58	0 52 66	3 57 24	278·777	15·491	71	3	...	...	1	1	...	1	2	...	...	...	
	Totals	29 30 70	1 52 80	31 03 50	1861·074	684·020	556	10	...	...	5	17	...	4	14	1* old	3	...	* Old reconnected.
Poona-Ahmednagar	November 1910	3 27 36	2 17 16	4 44 52	29·119	89·531	58	...	2*	...	...	1	...	1	1	...	...	...	
	December 1910	70 56 10	4 67 42	75 43 52	2572·812	2207·601	1,062	3	...	1	...	...	5	22	17	...	...	8	
	January 1911	3 55 76	0 10 30	3 66 06	135·564	133·524	49	...	1*	...	...	...	1	1	...	...	...	2	
	Totals	76 59 22	7 14 88	83 74 10	2737·495	2430·656	1,069	8	3*old	1	...	1	6	24	18	...	...	10	
Marmagao-Belgaum	January 1911	46 64 36	3 27 56	50 11 92	1353·502	364·265	648	3	...	...	4	12	2	21	1	...	...	...	
	February 1911	42 51 74	0 57 64	43 29 38	1670·065	424·090	556	2	...	...	...	...	1	18	18	...	...	...	
	March 1911	12 53 06	3 13 18	15 66 24	366·546	94·017	259	1	1*	1	...	1	1	8	1	...	1	...	
	Totals	102 09 16	7 18 38	109 27 54	3390·113	882·371	1,463	6	1*	1	4	13	4	47	20	...	1	...	
Belgaum-Hubli Revision	March 1911	47 39 76	0 39 16	47 78 92	2181·096	2257·955	887	1	...	...	7	9	...	22	7	...	...	...	
	April 1911	12 68 14	1 27 66	14 15 80	348·777	666·802	270	...	...	1	2	1	...	6	3	...	...	...	
	Totals	60 27 90	1 66 82	62 14 72	2529·873	2924·757	1,157	1	...	1	9	10	...	28	10	...	...	...	
Belgaum-Bāgalkot	April 1911	55 70 94	0 49 64	56 40 58	1910·460	2246·914	956	...	...	...	1	1	4	37	5	...	...	...	
	May 1911	33 52 22	0 40 32	33 12 54	757·378	1102·332	470	3	...	...	...	...	1	28	9	...	...	...	
	Totals	88 43 16	1 09 96	89 53 12	2667·838	3349·246	1,436	3	...	...	1	1	5	65	14	...	...	...	
	Grand Totals	357 10 14	19 02 84	376 12 98	13186·393	10271·050	5,771	23	4*	3	19	42	15	168	76	1* old	4	10	

TABLE III.—No. 2 DETACHMENT.

Tabular Statement of outturn of work, season 1910-11.

Section.	Month.	No. of miles double-levelling. Line.	Extras and Auxiliary.	Total.	Total No. of feet. Rise.	Fall.	No. of stations at which instrument was set up.	No. of bench-marks connected. Primary. Rock-cut protected.	Interred.	Engraved.	Standard.	Principal stations of triangulations.	Secondary. Embedded.	Inscribed.	P. W. D. and Irrigation.	Secondary station of Triangulation.	Rock-cut.	Remarks.
		mls. chs. lks.	mls. chs. lks.	mls. chs. lks.														
Connection of Dhubri Standard Bench-Mark.	Nov. 1910	...	1 22 06‡	1 22 06	6·147	8·534	28	...	...	1	1	...	...	3*	1	...	...	* Old.
Gauhāti to Dibrugarh	Nov. 1910	33 0 12	13 5 02‡	46 5 14	761·134	733·321	905	1	...	...	1	...	1+2†	16+1†	2	1	14	† Old being on rock *in situ* should be considered a primary bench-mark.
	Dec. 1910	81 33 20	0 41 80	81 75 00	629·350	597·204	1,026	1	...	...	...	...	...	54+1‡	...	...	5	‡ Mark on metal plate.
	Jan. 1911	82 22 72	0 16 32	82 39 04	1030·833	962·044	1,100	...	1	...	...	...	3	29	67	...	4	
	Feb. 1911	70 78 18	5 14 66	76 12 84	471·021	428·372	876	...	1	...	1	...	6	37	73	3	...	
	March 1911	...	0 63 12	0 63 12	...	...	35	...	...	...	...	...	11	...	...	...	...	
	TOTAL	267 54 22	19 60 92	287 35 14	2892·338	2720·941	3,942	2	2	...	1	3	21+2*	136+1*	142	4	23	* Old.
Gauhāti to Dumpep	March 1911	17 79 68	0 38 34§	18 38 02	2070·998	585·604	476	1	...	...	...	...	1	3	...	...	15	§ Includes check-levelling.
	April 1911	44 45 18	2 72 96	47 38 14	5322·068	1572·489	1,317	3	...	2	...	...	3	8	...	2	36	
	May 1911	8 13 06	0 1 16	8 14 22	936·376	343·094	211	1	...	...	...	...	...	5	...	...	5	
	TOTAL	70 57 92	3 32 46	74 10 38	8329·442	2501·187	2,004	5	...	2	...	...	4	16	...	2	56	
	GRAND TOTAL	338 32 14	24 35 44	362 67 58	11227·927	5230·662	5,974	7	2	8	3	...	25+2*	152+4*	143	6	79	* Old.

NOTE.—The total rises and falls on auxiliary li nes connecting G. T. stations are 3788·936 feet and 73·190 feet respectively.

TABLE III.—No. 3 DETACHMENT.

Tabular Statement of outturn of work, season 1910-11.

Section.	Month.	Number of miles of double levelling. Line. (mls. chs. lks.)	Extras and Auxiliary. (mls. chs. lks.)	Total. (mls. chs. lks.)	Total number of feet. Rises.	Falls.	Number of stations at which instrument was set up.	Number of bench-marks connected. Primary. Rock-cut preserved.	Primary. Standard.	Primary. Principal stations of triangulation.	Secondary. Old. Embedded.	Secondary. Old. Inscribed.	Secondary. Embedded.	Secondary. Inscribed.	Secondary. Rock-cut.	Remarks.
Ambālā to Solon	October 1910	...	3 45 82	3 45 82	...	...	55	...	1*	...	...	9	...	...	...	
	November 1910	49 27 56	0 20 06	49 48 22	300·71	92·7	789	1	...	...	...	...	4	30	6	
	December 1910	17 42 98	0 20 46	17 63 44	2342·7	1081·4	579	5	...	...	...	...	...	3	17	
	TOTAL	66 70 54	3 86 94	70 77 48	5349·8	1174·1	1,423	6	1	...	...	9	4	33	23	
Derā Ismail Khān to Chunda	December 1910	22 47 10	1 09 72	23 56 82	147·1	56·0	243	...	1*	...	1	6	...	8	...	
	January 1911	10 03 56	0 76 62	11 00 18	311·6	7·7	135	1	...	...	...	...	1	6	2	
	TOTAL	32 50 66	2 06 34	34 57 00	458·7	63·7	378	1	1	...	1	6	1	14	2	
Daryā Khān to Rāwalpindi with Auxiliary line to Shāhpur.	January 1911	58 47 18	4 63 74	63 30 92	448·8	414·0	628	...	...	2	...	2	3	7	...	
	February 1911	46 39 88	10 45 20	57 05 08	2492·2	461·7	886	1	...	...	...	...	5	15	10	
	March 1911	57 10 04	4 51 60	61 61 64	2309·1	3548·6	1,134	2	...	2	...	...	5	7	16	
	April 1911	49 25 36	16 19 18	65 44 54	1979·0	1703·0	66	2	1*	1	...	1	3	1	11	
	TOTAL	211 42 46	36 19 72	247 62 18	7229·1	6127·3	2,714	5	1	5	...	3	16	30	37	
Nowshera to Risālpur Cantonment	April 1911	2 64 60	0 10 70	2 75 30	17·8	60·8	29	...	...	...	1	4	...	...	...	
	May 1911	5 48 12	0 67 38	6 35 50	100·9	97·5	74	...	...	...	...	...	...	5	1	
	TOTAL	8 32 72	0 78 08	9 30 80	118·7	158·3	103	...	...	...	1	4	...	5	1	
Rāwalpindi to Murree	April 1911	2 68 72	0 29 18	3 17 90	13·1	62·0	44	...	...	...	1	6	1	1	...	
	May 1911	38 03 36	3 61 52	41 64 88	5685·7	629·5	1,079	6	...	...	...	...	...	2	26	
	TOTAL	40 72 08	4 10 70	45 03 78	5698·8	691·5	1,123	6	...	...	1	6	1	3	26	
	GRAND TOTAL	360 28 46	47 41 78	407 70 24	18855·1	8214·9	5,741	18	3*	5	3	28	22	85	89	

* Old reconnected.

TABLE IV.—No. 1 DETACHMENT.

List of Great Trigonometrical Survey stations connected by spirit-levelling.

Season 1910-11.

Name of station.	Height in feet above mean sea-level by		Difference, Triangulation —Levelling.	Remarks.
	Spirit-levelling.	Triangulation.		
Bābulsār H. S., *Bombay Longitudinal Series.*	2137·971	2140·79	+2·819	Height of lower mark-stone.
Yalūr H. S., *Mangalore Meridional Series.*	3285·456	3283·	—2·456	Height of upper mark-stone.
Navalur H. S. *Mangalore Meridional Series.*	2448·383	2445·	—3·383	Ditto ditto.

TABLE IV.—No. 2 DETACHMENT.

List of Great Trigonometrical Survey stations connected by spirit-levelling.

Season 1910-11.

Name of station.	Height in feet above mean sea-level by		Difference, Triangulation —Levelling.	Remarks.
	Spirit-levelling.	Triangulation.		
Assam Valley 1st Class Secondary Series.				
Dūmria H. S. . . .	2410·114	2,411	+0·886	Mark on rock *in situ.*
Chhintamanigarh T. S. . .	301·127	302*	+0·875	* Ground floor mark-stone.
Dibrugarh Church S. . .	395·461	394	—1·461	
Khanikar post S. . . .	338·279	336	—2·279	Upper mark.

NOTE.—Usually a list of G. T. S. principal stations is given. As no principal series exist along this route, this list of secondary stations is given in the belief that it may be useful.

TABLE IV.—No. 3 DETACHMENT.

List of Great Trigonometrical Survey stations connected by spirit-levelling.

Season 1910-11.

Name of station.	Height in feet above mean sea-level by		Difference, Triangulation —Levelling.	Remarks.
	Spirit-levelling.	Triangulation.		
Great Indus Series.				
Miānī T. S.	625·289	626·62*	+1·331	Height of ground floor mark-stone.
Heto T. S.	636·659*	636·65*	—0·009	This height refers to the new mark-stone at ground floor fixed in original position on account of the old having been uprooted.
Jatlā H. S.	2076·787	2076·	—0·787	Height of upper mark-stone.
Sidhr S.	1727·622	1728·	+0·378	Ditto ditto.
Surlā H. S. (*of Northern base line figures*).	2141·226	2142·	+0·774	Ditto ditto.

* These values are shown as Spirit-levelled values in Synoptical Volumes, but there is no record in any of the levelling Volumes.

Differences between Levellers (First-second) :—

No. 1 Detachment—

Line Kāsāra-Igatpuri.

At 12th mile (end of line)	−0·026 feet.

Line Poona-Ahmednagar.

At 50th mile	−0·019 „
77th „ (end of line)	−0·060 „

Line Marmagao-Belgaum.

At 50th mile	+0·053 „
„ 100th „	+0·089 „
„ 102nd „ (end of line)	+0·082 „

Line Belgaum-Hubli.

At 50th mile	+0·025 „
„ 60th „ (end of line)	−0·033 „

Line Belgaum-Bāgalkot.

At 50th mile	−0·145 „
„ 89th „ (end of line)	−0·234 „

The larger difference between the levellers on the Belgaum-Bāgalkot line is attributable to the unfavourable atmospheric conditions which prevailed when the line was run. The weather was hot and the readings of the staves at times were rendered uncertain by the *boiling* of the air, even though the lengths of the shots were reduced.

No. 2 Detachment—

Gauhāti-Dibrugarh.

At 50th mile	+0·003 feet.
„ 100th „	−0·055 „
„ 150th „	−0·024 „
„ 200th „	+0·002 „
„ 267th „ (end of line)	−0·052 „

Gauhāti-Dumpep.

At 50th mile	+0·031 „
„ 81st „ (end of line)	+0·037 „

No. 3 Detachment—

Line Ambāla-Solon.

At 50th mile	+0·083 „
„ 67th „	−0·030 „

Line Dera Ismail Khān-Chunda.

At 33rd mile (end of line)	−0·028 „

Line Daryā Khān-Rāwalpindi.

At 50th mile	−0·083	feet.
„ 100th „	−0·054	„
„ 150th „	−0·011	„
„ 200th „	−0·128	„
„ 212th „	−0·088	„

Line Rāwalpindi-Murree.

At 41st mile (end of line)	−0·081	„

PART VI.—MAGNETIC SURVEY.

NO. 18 PARTY,

(*Vide* Index map 11).

BY CAPTAIN R. H. THOMAS, R.E.

PERSONNEL.

Imperial Officers.

Captain R. H. Thomas, R.E., in charge from 20th March 1911.
Lieutenant H. T. Morshead, R.E., in charge from 1st October 1910 to 19th March 1911, and attached from 20th March to 15th September 1911.

Provincial Officers,

Mr. E. C. J. Bond, up to 21st July 1911,
Mr. H. P. D. Morton.
Mr. R. P. Ray.
Mr. N. R. Majumdar.
Mr. R. B. Mathur,

Lower Subordinate Service,

19 Surveyors, etc.

The present report deals with the work of the magnetic survey during the year 1910-11.

The report is divided into 3 main heads as follows :—

I.—An account of the operations in the field and work in recess quarters.

II.—A note on the working of the observatories during the survey year 1910-11.

III.—Tables of results comprising preliminary values of the magnetic elements at field and repeat stations in 1910-11 and the " quiet day " results at the survey base stations.

An index chart showing the progress of the magnetic survey is appended.

I.—FIELD OPERATIONS AND RECESS WORK IN 1910-11.

1. *Work of the field detachments.*—The field season commenced on the 20th October 1910 and closed on the 14th April 1911 when the party moved to recess quarters.

Four field detachments were employed during the year under report under Messrs. Bond, Morton, Ray and Mathur.

Magnetic survey of Kashmir.

Mr. Bond was employed in office duties during the cold season, and took the field in April in Kashmir. Twenty-nine new stations were observed, averaging 30 miles apart, the detachment returning to recess quarters early in July.

Detail survey in Bengal.

The Magnetic survey of the Andaman and Nicobar Islands, for which the census operations appeared to offer a favourable opportunity, had been included in the programme of Mr. Ray's detachment; at the last moment, however, the promised accommodation in the Census steamer was not forthcoming; and after observations at the repeat station at Port Blair and 3 new stations in the Andamans, the detachment was employed on detail survey in the vicinity of Buxar and Chāpra.

Mr. R. B. Mathur carried out a detailed survey of the Bengal coal-field in response to numerous requests for accurate values of magnetic declination; six meridian lines were also laid down to facilitate the testing of surveying compasses.

Observations at, and permanent marking of, old field stations, as additional "repeat" stations.

Mr. Morton was employed in re-observing at a number of old field stations which it is intended to re-occupy as additional repeat stations, in order to obtain further data for the secular changes in the magnetic elements.

Recent magnetic surveys have shown that these changes are far more complex and dependent on local and regional conditions than had previously been supposed, and it is therefore desirable to supplement the data available from the five observatories and 23 repeat stations, which are too far apart for the satisfactory determination of the secular changes over the entire region covered by the survey. The time and labor expended on accurate determination of the magnetic elements at any one time would be wasted, unless these changes are known with sufficient accuracy to obviate the introduction of serious error in the reduction of the observed values to a common epoch. "Repeat" observations at old field stations have been included in the annual programme since 1907; the field stations, however, were not permanently marked in the first instance as it was considered that, from the recorded description and observed bearings to prominent objects, the station could always be located within a few feet of the original site. Ordinarily an error of this amount in the siting of the instrument would be negligible, but in highly disturbed localities where the "station error" due to local disturbance varies widely in a small area, it is important to ensure the exact identification of the point previously occupied; for this reason Mr. Morton's stations have been marked by a concrete pillar, as in the case of the regular repeat stations.

2. *Field work of the officer in charge.*—During the field season one imperial officer only was available—Lieutenant Morshead, R.E.

The four survey base stations were inspected and comparative observations made at each and at Alībāg.

Twenty-two repeat stations were also visited.

3. *Work during recess.*—The computation of the previous season's field work and the reduction and tabulation of the base station results for 1910 have been completed.

Selection and computation of a new series of "quiet" days.

The selection and computation of the results of a new series of "quiet days" on which the traces are available at all the survey base stations have been completed. Hitherto the classification of the H. F. traces at the four survey observatories have been submitted to the Director, Alībāg Observatory, who subsequently selects and intimates the "quiet days" each month; many instances have, however, occurred in which the traces at one or other observatory have not been available for all the magnetic elements for one or more of the selected days and in these cases it has been the practice to substitute another quiet day for that observatory only.

The data derived from 5 quiet days per month are not, however, strictly comparable for various observatories unless the same days are used at each; uniformity in this respect is also desirable for survey purposes in the determinations of the corrections to field observations for diurnal variation and disturbance.

This new series of quiet days is not altogether complete; while in most cases it has been feasible to select 5 quiet days each month, occasionally 4 days and in a few instances 3 days only have been obtainable.

Proposed measurement of "all" days.

The main object of the introduction of the "quiet" day system was to effect a substantial saving in the labor required to obtain comparable results from various observatories, where the tabulation of all the curves was considered too serious a burden.

Losses of record are, however, at times inevitable and the system is therefore incapable of extension to an indefinite number of participating observatories; in India difficulties have sometimes arisen with only 5 observatories and, though these difficulties have been mainly due to unavoidable losses of record under circumstances unlikely to recur, the liability to such losses always exists owing to the observers in charge lacking the skill and knowledge required for other than superficial adjustments of the instruments.

The survey observatories were primarily established for the purposes of the magnetic survey; but while this end is amply served by the "quiet day" system and the selection of a series of quiet days applicable only to the survey observatories, the results are necessarily lacking in comparability with those of other observatories and the principle of the quiet day system is to that extent sacrificed.

Comparability can only be obtained by co-operation in an international series of quiet days or by the measurement of all days; of the two alternatives, the latter is to be preferred as being less likely to be affected by loss of records.

It has therefore been decided to introduce the measurement of all days from January 1912 as a tentative measure, at the same time transferring the labour of measuring the curves from the office of the magnetic party to the observers in charge of the base stations. The quiet day results will continue to be separately tabulated so that in course of time data will be available for the comparison of "quiet" and "all day" results.

4. *Instrumental differences in H. F.*—The imperial officers of the party have been mainly employed during recess in continuing the investigation of the instrumental differences in H. F., to which reference has been made in the reports of the last two years: this work, it is hoped, will be shortly completed and the following summary of the various steps in the investigation may be of interest.

It has been customary to compare the field instruments with the Dehra standard twice each year, at the beginning and end of each field season; observations with the field instruments are as far as possible simultaneous, site errors being eliminated by exchange of stations: the comparisons are made through the magnetograph curves, for the standardisation of which additional observations are made with the standard instrument during the comparisons.

The resulting instrumental changes showed considerable variations; these could only be due to (*a*) error of observation, (*b*) changes in instrumental constants, or (*c*) real changes in the indications of various instruments, which are separately considered below.

(*a*) Observational errors.

A complete determination of H. F. requires vibration and deflection experiments giving mH and $\frac{m}{H}$, from which "m" and H are found: usually however vibration experiments are made just before and after the deflection and the mean of the two values adopted as the value of H. F. applicable to the mean epoch of the observations.

The value of "m" generally decreases slowly, but not always regularly, owing to the accidental jarring or shocks which a magnet may experience from time

to time, so that for short periods "m" may be regarded as constant; H on the other hand is constantly undergoing changes, some periodic, others non-periodic, and varies from place to place: the successive values of "m" therefore afford a means of testing the accuracy of the observations.

Errors of observation in the determination of H. F. may therefore be due to two causes, *viz.*, change of H. F. and declination during the time occupied in the determination, and accidental error due to mistake in observation; in both cases the values of "m" and H are affected.

The probable error of a single determination of "m" and H may be considerable: but the chances of error are greater in the vibration than in the deflection experiment for two reasons: firstly, the intrinsic difficulty of the former observation and, secondly, on account of the greater length of time occupied in the vibration observation.

(The complete deflection observation occupies considerably longer time than the vibration, but the observations at 22·5 cms. only are used for determining H. F., the remainder serving only for the evaluation of the distribution coefficients P and Q; the average time required for the observations at 22·5 cms. is approximately 6 minutes against 10 minutes for the vibration experiment.)

It was therefore thought that errors of observation could as far as possible be eliminated by the recomputation of the values of H. F. from the deflection results only, using mean values of "m"; the mean value of "m" was obtained from the smoothed curve drawn through a series of plotted values each of which was the mean of 12 or more successive single values.

This method of computation was in the first instance applied to the base station observations, where the base line observations offered a ready means of testing any resulting improvement over the former method. In practically every case the probable error of the mean base line value was considerably diminished and the general symmetry of the curve of base line values improved. The observations with the field instruments were then recomputed, and the method adopted for future use.

There was a slight corresponding improvement in the instrumental differences, but on the whole the character of the variations remained unchanged.

It had been found, however, that, in drawing the smoothed curves of "m" for different instruments from which the mean values of "m" were scaled, the observed values of "m" did not in all cases decrease with lapse of time, increases of value being occasionally exhibited for short periods and the next step in the investigation was to consider the possibility of eliminating these apparent increases by considering change in instrumental constants.

(*b*) Change in Instrumental constants.

The constants which contribute appreciably to the observed value of H. F. are (1) the temperature coefficient, (2) the moment of inertia, and (3) the distribution coefficients P and Q.

(1) Chree has shown (Proc. Roy. Soc. Vol. 65) that there is no clear relationship between the temperature coefficient "q" and "m", and consequently no reason to suspect a change in "q" as a magnet grows weaker with age. Even if such a tendency existed, the short period which has elapsed since the magnets were magnetised and the comparatively small diminution in their respective magnetic moments, would afford sufficient grounds for neglecting changes in "q" as a contributory cause of the observed instrumental changes.

(2) No account was taken of changes in the moments of inertia of the survey magnets in computing the instrumental differences; there is some uncertainty as to the correct initial values of the moment of inertia of the field magnets at the beginning of the survey for the reason given in the report for 1904-05, though the values for the standard instrument are however known from year to year with probably very fair accuracy.

It was therefore considered advisable to wait until the values of the moment of inertia K were available for subsequent years, from which values for the preceding period could probably be deduced.

Observations since 1906, in which year the absolute moments of inertia of the auxiliary standard inertia bars were accurately determined, have shown that the decreases in the value of K since that year are very small for all the survey magnets: the values of K for the standard from 1902 to 1906 would seem to indicate that the rate of decrease is relatively more rapid when a magnet is first taken into use.

It is tolerably certain that the change owing to decrease of K has been greatest in the standard magnet and this, if changes in the moment of inertia were alone responsible for the variations in instrumental differences, should be shown by an increasing divergence of those differences, when those are based on values computed with a constant moment of inertia.

The irregularities of the observed variations in instrumental differences were however such that the correction for progressive change of the moment of inertia could have little effect on these irregularities, and it was therefore decided that correction on this account might more appropriately be deferred to a later stage of the investigation.

(3) Hitherto the values of $\frac{m}{H_h}$ in the deflection experiment had been computed using the value $1 \frac{P}{r^2 h}$ when P was derived from observations at two distances, the value of P used in computation being the mean of the year for base stations and for a season's work for the field instruments; very occasionally means were taken out for intermediate periods when there was evidence of apparent change.

Observations were however invariably taken at a third distance, but the correction on account of the Q term was left to the final reduction.

It was previously mentioned that in deriving the curves of "m" for various magnets anomalous increases of "m" of comparatively small amount were sometimes met with which could neither be ignored on account of their magnitude and duration, nor attributed with any certainty to errors of observation; sudden falls of "m" of varying account had also occurred in almost all the magnets.

Displacements of the magnetic axis had been sometimes found to coincide with these latter, and it seemed reasonable to suppose that, if changes in the distribution constants really did occur, they would most probably be associated with these decreases in the value of "m"; apparent increases of "m" might be accounted for on the same hypothesis, and eliminated by changes in P and Q if these could be substantiated.

Preliminary inspection of the values of $P_{1 \cdot 2}$ and $P_{2 \cdot 3}$ (being the values from observations 22·5 and 30 cms. and 30 and 40 cms. respectively) of the survey standard seemed to indicate that several changes in P and Q had occurred and the term $(1 + \frac{P}{r^2} + \frac{Q}{r^4} + \ldots)^{-1}$ was then computed for various periods, the grouping of which was determined partly by evidence of change in either $P_{1 \cdot 2}$

or $P_{2 \cdot 3}$ and partly by sudden changes in "m_0": the process was subsequently extended to the other observatory and field instruments.

For the observatory instruments, the base line values of the magnetographs and the resulting monthly mean values of H. F. afford a means of testing the reality of the apparent changes found from the magnetometer observations; no assumed change in the coefficients can be accepted which results in a dislocation of the base line which is unconfirmed by visual inspection of the curves, while a sudden change in the mean value from one month to another which is confined to one observatory is at least open to suspicion.

Applying these tests, it was found that, in the observatory instruments there were no grounds for assuming real changes in P and Q, except on one occasion in the standard instrument at Dehra, *viz.*, from May 9th, 1908, when there was a sudden fall of "m" amounting to 17 C. G. S. units, the new values of P and Q applying to all observations made since that date.

For the field magnets, there are no such facilities for testing the variability of P and Q as in the observatory magnets, but fortunately the values of P and Q computed for various periods, as in the observatory instruments, are, with one exception, in such good agreement that it is certain that no change in these constants can have occurred: in the single case where there was an undoubted change, there was also a sudden fall in "m" of 70 C. G. S. units.

Sudden falls of "m" have not been uncommon in the field magnets, as might be expected from the shocks and jars of travelling; and the fact that even under these conditions P and Q remain unchanged affords additional and stronger evidence that the changes in these constants for the standard magnet cannot be real.

The cause of these apparent changes which generally are so abrupt as to be unmistakeable, is not clear; but they usually coincide with dislocations of the curve of "m" and are of short duration, the values of P and Q then returning to the previous values, and it therefore seems possible that they may be due to a temporary alteration of the normal magnetic conditions owing to the proximity of magnetic material: if this theory is correct it would account for the fact that these apparent changes are usually only met with in the base station observations.

On the whole, then, it may be concluded that real and permanent changes in the distribution constants are rare: real changes need only be looked for when there has been a large and sudden fall in the value of "m", and even in such cases changes are comparatively infrequent.

This conclusion is important but the variations in instrumental differences still remain unexplained; some slight improvement resulted from the substitution of a constant value of $1-\frac{P}{r^2 h}$ for periodic values (yearly or seasonal) hitherto used, but the Q term was shown to be a constant for any particular magnet.

Changes in the magnetic constants need not then be considered in the investigation, observational errors had apparently been eliminated as far as possible, and there seemed no alternative but to regard the changes as due to real instrumental change.

(c) Real instrumental changes.

Apart from actual damage to a magnetometer resulting in serious alteration of the assumed deflection distances, it is difficult to imagine how an instrumental change can occur, other than one in the constants: the constants, which affect the value of H.F., are the temperature coefficient, distribution

coefficients and the moment of inertia; it has been shown that change in the temperature coefficient need not be considered, in the distribution coefficients rarely (and changes in the latter are readily found from the observations themselves), and the moment of inertia is periodically re-determined.

The hypothesis of real instrumental change was therefore entertained with reluctance, the more so that the irregularities in the instrumental changes could only be explained by accepting frequent changes in both the standard and field instruments.

Instrumental changes, permanent or temporary, were considered to be likely to coincide with abrupt dislocations of the magnetic moment, which might conceivably be regarded as the result of considerable molecular disturbance.

In last year's report several examples of apparent instrumental change, permanent and temporary, were given, which were coincident with sudden decreases of magnetic moment: the evidence in support of these changes was apparently unimpeachable and if these instrumental changes had really occurred, the frequency of the changes in the instrumental differences might for the most part be plausibly explained, sudden falls of magnetic moment being a not uncommon experience with the field instruments, though it would still be difficult to account for changes when no abnormal decrease of "m" had conveniently occurred.

Further investigation during the past recess season has however shown that the instrumental changes suggested in the last report cannot be substantiated.

It has now been found that the data from which the temporary change in the standard instrument in May 1908 was deduced, were incorrect: the selected mean temperature for the Dehra observatory was increased from 25° to 27° from January 1909, and in computing the instrumental differences through the magnetograph curves during the recess season of 1909, the new mean temperature was inadvertently applied to some of the instrumental comparisons of May 1908. The temperature coefficient is $12{\cdot}6\gamma$ per 1°C and the error thus introduced amounts to 25γ which is precisely the amount of temporary change deduced from the erroneous data: that the standard appeared to have reverted to former conditions in October 1908 is due to the comparisons for that month having been correctly computed.

Examples of permanent instrumental change were also given at Barrackpore and Kodaikānal.

In the latter case, the correct value of "m" for any particular observation is somewhat uncertain owing to rapid changes in the observed values, while there is reason to suppose that the autographic instrument was not working satisfactorily; at Barrackpore the apparent change is due partly to an assumed change of the distribution coefficients which is probably incorrect, and partly to interference in the autographic instrument which was opened up and re-adjusted during December 1906.

At Barrackpore, moreover, there was a change of observers during December 1906, and this leads to the consideration of what is most probably the real explanation of the majority of the observed changes in instrumental differences, *viz.*, "personal equation" between observers in the determination of H. F., which in this instance was masked by the large fall of magnetic moment which occurred at the same time as the observers were changed.

Personal equation and personal error.

Personal equation was alluded to in last year's report but the significance of this factor in the measurement of Horizontal Force was underestimated for want of data from which the cause of personal equation could be deduced: further it was thought that personal equation would be a constant for any one observer for considerable periods and corrections therefore easily applied.

Personal equation may be defined in this connection as the difference of the mean values of the magnetic moment for the same magnet obtained by different observers, the mean epoch of the observations being approximately the same in each case.

Each observer may have a personal or absolute error: thus the apparent absence of personal equation on interchanging observers may mean either that *at that particular time* their absolute errors were *nil* or of the same amount.

Experiments have since shown that personal equations are largely and probably wholly attributable to errors of observation in the vibration experiment.

Personal error in the determination of H. F. may be further defined as the difference in the mean magnetic moment obtained by the same observer when the vibration observations are taken

(*a*) by the eye and ear method;
(*b*) by the electric chronograph.

Experiments, in which observers were interchanged, have shown that while for the majority of observers results are practically identical when using the chronograph, serious divergencies, as in the case of observations of star transits, are found in the former method; further "personal error" is by no means necessarily a constant for a particular observer (though it may be so for short periods), but may vary during the limits of a single field season.

The cause of the error appears to lie in the estimation of the time interval elapsing between the clock beat and the transit of the centre of the scale by the moving cross wires, the magnitude of the error varying with the amplitude of the arc of vibration, which diminishes by about one half during the observation. In this respect the observation differs from that of star transits.

The magnitude of the effect of a timing error may be shown by the following example: with a magnet having a moment of 900 C. G. S. units and a moment of inertia of 3·4 (which are the average values of the survey magnets), a difference of 0·2 seconds in the mean value of the several series of 162 vibrations will produce at Dehra Dūn an error of 0·4 unit in magnetic moment and an error of 14γ in H. F., *i.e.*, such small errors as 0·1 second in opposite directions in the two series of vibrations would be sufficient to account for the discrepancy.

Attention was first drawn to personal error, as a factor to be considered in the determination of H. F., late in 1909, when dealing with the observations at Kodaikānal during the previous year.

In July 1908 the permanent observer proceeded on three months' leave; immediately after the change of observers the magnetic moment fell 0·46 C. G. S. unit and the base line 19γ both returning to their previous values when the permanent observer resumed his duties.

It was clear that a personal equation existed, but the cause was not at first sight apparent: the individual value of "m" were in excellent agree-

ment but were consistently high in the one case and consistently low in the other.

On recomputing the base lines, however, from the deflection observations only of both observers, *using the same mean value of magnetic moment throughout* it was found that the base lines were now in good agreement and it was plain that the personal equation must be due to persistent error in the vibration observations.

Experiments were then made at Dehra Dūn, where an electric chronograph is available, with the standard instrument; in December 1909 it was found that the observer's personal error was *nil*, the mean magnetic moment by chronograph agreeing with that found by the eye and ear method, and it therefore seemed possible that the error at Kodaikānal might be an isolated case and dependent upon special causes connected with the change of observer.

Further experiments however at Dehra in March 1910 showed that the observer had developed a personal error of 0·4 unit since the previous December, and it was therefore decided to carry out further trials with the field instruments on return to recess quarters in April 1910: as an additional precaution, in several cases observers and instruments were interchanged.

It was found that while the chronograph values of "m_0" of different observers were in excellent agreement, those obtained by the eye and ear method showed at times considerable divergencies.

As a result of these experiments, the observer at Dehra Dūn was ordered to take a series of vibrations with the chronograph at intervals of about six weeks, and it was decided to include similar series in the bi-yearly comparisons of the field instruments.

The latter were inadvertently omitted in October 1910 but have been carried out in April and October of the present year.

The table below shows the personal errors of the field observers at these times; where a second value is given in brackets the error is that of a second observer: a plus sign means that the "eye and ear" determination of "m" is higher than the chronographic.

	2 A	3 A	5 A	4 A	6 A	10
April 1910 .	±0·0	±0·0	—0·4	+0·2	+0·8 (±0·0)	±0·0 (—0·2)
April 1911	Magnet 2A not used.	—0·6	—1·1	±0·0	+0·8	+0·2
October 1911			—0·6		+0·6	—0·4

In the case of magnet 6A it looks as if the errors were constant, while with 3A and 5A it might have been gradually developed during the interval, but inspection of the plotted mean values of "m" for short periods shows that this is not the case and the error probably varies within small limits while preserving the same sign; it is perhaps possible that in the field instruments the variation may have some connection with the value of H. F. and the consequent rate of vibration, though it is more likely to be dependent on the observers' physical condition.

Personal error in the determination of H. F. does not appear hitherto to have received the attention it deserves in connection with magnetic work: that it escaped earlier attention in the Indian survey is due to the fact that though there had been a number of cases in which observers were interchanged, there was either no unmistakeable evidence of personal equation

at the time of change, or the change was coincident with a decrease of the value of "m" sufficient to mask the effect of personal equation.

Since then personal error is probably the main cause of the observational discrepancies, it follows that with the survey standard there is practically as much liability to observational error when using the eye and ear method as with the field instruments; consequently comparatively unimportant but unexplained divergencies in comparative results raise a doubt which extends even to the results of the standard magnetometer. The necessity therefore arises not merely of correcting the field instruments to the standard but also of correcting the observations of the standard itself.

Importance of the investigation of the instrumental differences.

It proves then to have been advantageous that the discrepancies in comparative results were given more careful attention than they might previously have appeared to call for.

Since there appears to be no reason for anticipating changes in the indications of magnetic instruments other than those due to change of constants, for which correction is made in the ordinary course, it follows that if the differences between instruments are accurately known at any particular time, any departure from those of differences at another time must be due to varying personal errors and change of constants. From the foregoing discussion it will be evident that changes in constants other than the moment of inertia need not be further considered.

Method of correcting the standard instrument.

In comparing the instrumental differences it has been found more advantageous to compare the values of the base lines of the magnetograph found from various instruments at the time of comparisons, rather than to reduce all instruments to the standard by means of the curves; this course is the more advisable in cases where the comparisons have been made at various times and the "personal error" with the standard therefore liable to variation.

The comparisons with the chronograph since April 1910 have shown that the differences of instruments have remained constant and it therefore follows that determinations of H. F. in which the chronograph has been used for the vibration experiments may be accepted with confidence both as regards the value of H and "m."

Any one of the chronographic comparisons since April 1910 may then be taken as the point of departure or zero, from which the differences of base lines for each instrument for comparisons previous to 1910 may be measured; if there were no personal error these differences would be the same in all cases (except for small and uniform changes due to change in the moment of inertia); wide divergencies are however found and the solution of the problem lies in the determination of the most probable personal errors for each instrument compared.

Fortunately the problem has been simplified by the fact that similar chronographic determinations of H. F. were made in 1902 with all the instruments (the chronograph was used solely as a time saving machine, the existence of "personal error" being unsuspected); these observations, which were taken at the beginning of the survey, have been of great service in deducing the changes in the various moments of inertia, thus leaving "personal errors" alone to be dealt with.

The probable personal errors at any point of comparison are limited by the condition that the value of "m" accepted can in no case exceed the value accepted for the previous comparisons.

In this way the most probable value for the difference of base line during any comparison from the zero point may be found, and hence the base line for the standard at the time of comparison, from which the moment of the standard magnet can be deduced.

The moment of the standard can thus be determined for two points each year corresponding to the time of the bi-yearly comparisons, and intervening values can be found by interpolation when the change in the interval has been small: from these values the mean base lines and monthly mean values can be recomputed.

At the other observatories comparisons are made only once a year with usually a single instrument, and the accuracy of the determination of the "personal error" depends on the accuracy of the interpolated value of "m" of the travelling instrument. It is however probable that the decrease of moment in a magnet proceeds uniformly, and sudden falls of "m" do not affect the rate of decrease: the rate of decrease of "m" with the majority of the survey magnets is moreover so small that errors of interpolation should usually be negligible.

The investigation is still in hand and will be referred to more fully in the next report; it is hoped the above outline of the method adopted will suffice to show that the elimination of "personal errors" is to a large extent a "trial and error" process and therefore necessarily laborious; the final test, lies in a comparison of the monthly mean values of H at the various observatories after correcting for secular changes. For the purpose of this comparison it is necessary to have the same series of quiet days, and this was an additional reason for the selection and computation of a new series of days, to which reference was made earlier in this report.

Other causes of change in instrumental differences.

There are two other causes of discrepancies which may be briefly noticed and which the preliminary correction for "personal errors" does not altogether preclude.

These are—

(*a*) Thermometric errors.

(*b*) Temporary change in the magnetic field due to the presence of magnetic material.

Thermometric errors include (1) the gradual zero-creep inseparable from all mercury in glass instruments, and (2) those due to unexpected changes of correction such as a slight dislocation of the mercury column.

The former have been guarded against by redetermination of the zero point; instances of the latter are however not infrequent in India especially in horizontal thermometers such as in the deflection observation.

Several thermometers have been rejected for the latter trouble and it is possible that in some cases there were unsuspected errors at the time of comparison.

The second cause of error is probably rare though there appears to be an undoubted instance in Dehra Dūn observatory in October 1903; the possibility of such an error was alluded to in the report for 1904-05 in discussing the change in the differences of declination between the North and South houses.

It is probably due to other magnets not having been removed to a safe distance; the values of P, "m" and H may be altered.

Only one instrument will usually be affected, and in such cases the observations must be rejected and the probable value of the base line found from the remaining instruments.

II.—WORKING OF THE OBSERVATORIES.

A.—DEHRA DŪN OBSERVATORY.

1. *General remarks on working.*—The observatory remained in charge of Surveyor K. K. Dutta until March 1911, when he was relieved by magnetic observer Shri Dhar.

The magnetographs have given good results throughout the year; the V. F. instrument, as usual, required the balance to be adjusted on several occasions.

The rainfall in 1911 was much below the average and there was consequently no difficulty in keeping the under-ground room dry: the proposed plastering of the walls and floor to prevent the percolation of subsoil water has been postponed to enable the observatory to co-operate in the special programme of observations arranged in connection with the British Antarctic expedition, and will be put in hand in the beginning of May next.

2. *Mean values of H. F. and declination constants.*—The following table gives the mean monthly values of the magnetic collimation, and the distribution co-efficients $P_{1\cdot 2}$ and $P_{2\cdot 3}$ and the mean value of "m_o" used in the computation of the results for 1910:—

Mean values of the constants of the Magnetometer No. 17 in 1910.

MONTHS.	DECLINATION. CONSTANTS.	H. F. CONSTANTS.						REMARKS.
		MEAN VALUES OF P'S.						
	Mean magnetic collimation.	$P_{1\cdot 2}$	$P_{2\cdot 3}$	Accepted value of $P_{1\cdot 2}$	Accepted value of $P_{2\cdot 3}$	Mean value of "m."	Accepted value of "m."	
January	−9′: 33″	7·20	7·24	7·17 throughout.	7·51 throughout.	The monthly values showed considerable irregularities probably due to variable personal error.	893·31 throughout.	The accepted values of $P_{1\cdot 2}$ and m_o are those used in the computation of Base Line values of mean monthly values of H. F.
February	: 34″	7·29	7·32					
March	: 39″	7·14	7·69					
April	: 45″	7·30	7·70					
May	: 39″	7·25	7·30					
June	: 39″	7·20	7·50					
July	: 38″	7·08	7·62					
August	: 39″	7·09	7·54					
September	: 41″	7·13	7·52					
October	: 41″	7·13	7·68					
November	: 37″	7·15	7·52					
December	: 40″	7·15	7·63					

3. *Mean base line values.*—The table below gives the mean values of the H. F. and declination base lines, actually used to obtain the values of force, etc., given in the tables at the end of this report.

The values of H. F. and V. F. should be regarded as preliminary only, pending the results of the investigation into the subject of "personal error" and the addition of the Q term : the present values have been obtained in the same manner as those of previous years, with which they are therefore directly comparable.

The V. F. base lines are not given : irregular changes of base line are to be expected in these instruments, the effects of which are minimized by the practice of observing values of dip daily with the Schultze earth inductor.

Abstract of Base Line values of Magnetographs in 1910.

Months 1910.	Declination. Mean observed value of base line.	Declination. Base line accepted.	Declination. Remarks.	Horizontal Force. Mean observed value of base line.	Horizontal Force. Base line accepted.	Horizontal Force. Remarks.
January	1° : 45′·5		The curves at times showed signs of interference.	·33017	·33018	
February	44′·4	1° : 44′·4		·33020	·33018	
				·33016	·33018	Up to 7th March at 10 h. 5 m.
March	44′·1	44′·1	...	·33166	·33166	7th March at 10 h. 33 m. to 12th March at 10 h. 5 m
				·33086	·33088	12th March at 10 h. 33 m.
April	43′·5	43′·5	...	·33088	·33088	
May	43′·9	43′·6	to 16th	·33089	·33088	
		44′·4	from 18th	...	...	
				·33087	·33088	Up to 14th.
June	43′·8	8′·8	...	·33156	·33156	Up to 18th.
				·33012	·33012	From 23rd instrument re-adjusted.
July	43′·6	...	...	·33009	·33009	
August	43′·3	...	...	·33008	·33008	Up to 15th.
					·33006	From 16th.
					·33004	1st to 10th.
September	43′·6	43′·6	...	·33001	·33002	11th to 20th.
					·33000	21st to end.
October	44′·3	44′·3	...	·32998	·32998	
November	44′·2	44′·2	...	·32996	·32996	
December	44′·4	44′·2	...	·32994	·32994	

4. ***Mean scale values and temperature ranges.***—The mean scale value of the H. F. magnetograph was 4·09γ for an ordinate of 0·04 inch up to June 23rd, 1910, when the instrument was re-adjusted and the torsion head turned after which the value rose to 4·12γ.

The mean scale value of the V. F. instrument varied from 4·4γ to 5·3γ.

The mean temperature of the observatory for the year was 27°·2 C, the maximum and minimum monthly mean values being 27°·3 C and 27°·2 C, which is very satisfactory: the temperature of reduction is 27° C.

The mean scale value of the declination instrument remained 1·03 (minutes) for an ordinate of 0·04 inch.

5. *Mean monthly values and secular change, 1909-10.*—The following table gives the mean monthly values of the magnetic elements for 1909-10 and the changes during that period deduced therefrom. There appears to have been an increase in the rate of secular change in Declination, which is confirmed by the results from the other Survey Base stations :—

Secular changes at Dehra Dūn in 1909-10.

MONTHS.	HORIZONTAL FORCE ·33000 C. G. S.+			DECLINATION E. 2°+			DIP N. 43°+			VERTICAL FORCE ·31000 C. G. S.+			REMARKS.
	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January . . .	278	263	−15	36·0	33·4	−2·6	45·1	52·0	+6·9	859	972	+113	
February . . .	286	261	25	35·8	33·4	2·4	45·7	52·2	6·5	876	974	98	
March . . .	277	266	11	35·6	33·3	2·3	45·9	52·4	6·5	872	982	110	
April . . .	297	256	41	35·0	32·2	2·8	45·4	53·1	7·7	883	986	103	
May . . .	290	270	20	34·8	32·2	2·6	46·3	53·5	7·2	893	1,006	113	
June . . .	296	264	32	34·6	31·8	2·8	46·6	54·3	7·7	903	1,015	112	
July . . .	293	269	24	34·7	31·3	3·4	46·7	54·8	8·1	902	1,030	128	
August . . .	292	253	39	34·4	31·4	3·0	46·8	55·6	8·8	902	1,029	127	
September . .	265	255	10	34·1	31·1	3·0	51·2	56·0	4·8	959	1,039	80	
October . . .	234	241	+ 7	34·6	31·3	3·3	52·3	57·7	5·4	951	1,056	105	
November . . .	246	243	− 3	34·3	30·9	3·4	51·5	58·1	6·6	946	1,067	121	
December . . .	258	248	10	33·2	30·4	2·8	51·9	58·1	6·2	965	1,071	106	
Means .	276	257	−19	34·8	31·9	−2·9	48·0	54·8	+6·9	909	1,019	+110	

B.—BARRACKPORE OBSERVATORY.

1. *General remarks on working.*—Magnetic observer K. N. Mukerji was in charge of the observatory throughout the year.

The magnetographs worked satisfactorily throughout. It was noted in last year's report that the H. F. base line at Barrackpore showed considerable annual variation, a rapid fall in November and December being followed by a sharp rise in February and March, the values for the period May to October remaining practically unchanged. The cause of this variation which is most marked at Barrackpore remains obscure ; it was thought to be connected with the annual range of temperature of the observatory which is decidedly larger at Barrackpore than elsewhere and this view received support from the fact

that at Kodaikānal where the temperature range was least, there was practically little or no indication of annual variation.

The monthly mean temperatures at Barrackpore during 1910 however show so little variation that the connection of the phenomenon with temperature is doubtful, though it may be remarked that the agreement of the monthly mean temperatures is somewhat fortuitous, the temperature range in some months being considerable.

The mean monthly values of force computed with the observed base lines, exhibit an annual variation which accords with that obtained from other observatories, and the base line variation cannot be due to changes in temperature co-efficient or scale value; it therefore seems clear that the variation is due to mechanical and not magnetic causes.

2. *Mean values of H. F. and declination constants.*—The table below gives the mean monthly values of the Declination and H. F. constants during 1910:—

Mean values of the constants of the Magnetometer No. 20 in 1910.

MONTHS.	DECLINATION CONSTANTS.	HORIZONTAL FORCE CONSTANTS.						REMARKS.
		MEAN VALUE OF P's						
	Mean magnetic collimation.	$P_{1\cdot3}$	$P_{2\cdot3}$	Accepted values of $P_{1\cdot3}$	Accepted values of $P_{2\cdot3}$	Mean value of "m."	Accepted mean value of "m."	
January . .	—7′: 55″	6·62	7·58			940·23		The accepted values of $P_{1\cdot3}$ and "m_o" are those used in the computation of the results for 1910.
February . .	: 53	6·49	7·65			940·22		
March . . .	: 55	6·59	7·73			940·25		
April . . .	: 56	6·67	7·67			940·19		
May . . .	: 57	6·61	7·73	6·69 throughout.	7·64 throughout.	940·19	940·21 throughout.	
June . . .	: 55	6·65	7·76			940·18		
July . . .	: 53	6·76	7·50			940·21		
August . .	: 58	6·85	7·45			940·14		
September . .	: 55	6·67	7·52			940·16		
October . .	: 54	6·79	7·68			940·16		
November . .	: 55	6·73	7·56			940·23		
December . .	: 56	6·78	7·82			940·30		

3. *Mean Base Line values.*—The following table gives the mean observed values of the Base Lines of the Declination and Horizontal Force of mag-

netographs: the accepted values are those actually used in the computation of the monthly mean values.

The V. F. base lines are not given owing to frequent changes.

Abstract of base line value of Magnetographs in 1910.

Months 1910.	Declination.			Horizontal Force.		
	Mean observed value of base line.	Base line accepted.	Remarks.	Mean observed value of base line.	Base line accepted	Remarks.
January	—0° : 4′·7	—0° : 4′·7		·37051	·37051	
February	: 4·8	: 4·7		·37049	·37049	
March	: 4·7	: 4·7		·37051	·37051	1st to 16th.
					·37053	17th to 21st.
					·3·055	22nd to 26th.
					·37057	27th to 31st.
April	: 4·8	: 4·7		·37065	·37060	1st to 5th.
					·37063	6th to 10th.
					·37065	11th to 30th.
May	: 4·7	: 4·7		·37066	·37066	1st to 15th.
					·37068	16th to 23rd.
					·37070	24th to 31st.
June	: 4·7	: 4·7		·37073	·37072	1st to 10th.
					·37073	11th to 30th.
July	: 4·7	: 4·7		·37072	·37072	1st to 16th.
					·37074	17th to 23rd.
					·37077	24th to 31st.
August	: 4·7	: 4·7		·37082	·37080	1st to 10th.
					·37082	11th to 31st.
September	: 4·7	: 4·7		·37084	·37084	
October	: 4·6	: 4·7		·37080	·37080	1st to 15th.
					·37077	16th to 23rd.
					·37074	24th to 31st.
November	: 4·8	: 4·7		·37069	·37071	1st to 8th.
					·37069	9th to 16th.
					·37067	17th to 21st.
					·37065	22nd to 26th.
					·37063	27th to 30th.
December	: 4·7	: 4·7		·37055	·37060	1st to 6th.
					·37057	7th to 12th.
					·37055	13th to 31st.

4. *Scale values and temperature range.*—The mean scale values for the year are as follows:—

$$\left.\begin{array}{lll} \text{H. F.} & . \quad . & 4{\cdot}86\gamma \\ \text{Declination} & . \quad . & 1{\cdot}03 \text{ minutes} \\ \text{V. F.} & . \quad . & 4{\cdot}52\gamma \end{array}\right\} \text{for an ordinate of } \tfrac{1}{25}''.$$

The mean temperature of the observatory for the year was 32°·2 C with maximum and minimum monthly values of 32°·2 C and 31°·4 C: the range in

several months was however considerably greater than these figures would suggest.

The temperature of reduction is 31° C.

5. *Secular changes, 1909-10.*—The following table gives the mean monthly values of the magnetic elements for 1909 and 1910 and the secular changes during the interval :—

These values should be regarded as preliminary only.

Secular changes at Barrackpore in 1909-10.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION E. 0°+			DIP N. 30° +			VERTICAL FORCE ·22000 C. G. S. +			REMARKS.
	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January . . .	301	318	+17	62·9	58·1	−4·8	36·8	40·3	+3·5	71	133	+62	
February . . .	307	317	10	62·5	57·6	4·9	36·6	40·9	4·3	72	141	69	
March . . .	295	323	28	62·2	57·4	4·8	37·5	40·8	3·3	78	143	65	
April . . .	315	320	5	61·6	56·6	5·0	37·0	41·6	4·6	82	153	71	
May	309	331	22	61·1	56·1	5·0	37·6	41·9	4·3	88	164	76	
June . . .	310	330	20	60·9	55·8	5·1	38·1	42·1	4·0	96	167	71	
July	308	337	29	60·6	55·2	5·4	38·7	42·0	3 3	103	168	65	
August . . .	303	336	33	60·2	54·5	5·7	39·1	42·9	3·8	106	181	75	
September . .	291	341	59	59·8	54·2	5·6	40·4	43·0	2·6	118	186	68	
October . . .	261	327	66	59·7	54·0	5·7	42·0	43·6	1·6	123	187	64	
November . .	293	331	38	59·2	53·5	5·7	40·3	44·1	3·8	117	196	79	
December . .	302	341	39	58·2	52·8	5·4	40·8	43·5	2·7	130	193	63	
Means . . .	300	329	+29	60·7	55·5	−5·3	38·7	42·2	+3·5	99	168	+69	

C.—TOUNGOO OBSERVATORY.

1. *General remarks on working.*—The observatory remained in charge of Abdul Majid during the year.

The H. F. and declination magnetographs worked satisfactorily throughout the year.

The V. F. magnetograph which had given trouble during the latter months of 1910 owing to frequent changes of zero, was readjusted by the officer in charge in December 1910. This readjustment was not altogether successful and a further readjustment was found necessary in July 1911 : it is feared that the curves for the intervening period will have to be rejected.

2. *Mean values of H. F. and Declination constants.*—The following table gives the mean monthly values of the magnetic collimation $P_{1\cdot 3}$ and $P_{2\cdot 3}$ and the

magnetic moment during 1910: the accepted values of $P_{1 \cdot 2}$ and "m_0" are those used in the computation of the observatory results:—

The magnetic moment of magnet 19A continued to decrease rapidly throughout the year; this rapid decrease has been exhibited since the magnet was taken into use in May 1908 and it is evident that the magnet was not properly "aged" by the manufacturers. The rate of decrease was less rapid in 1910 and it is hoped this improvement will continue.

Mean values of the Constants of the Magnetometer No. 19 in 1910, with Magnet No. 19A.

MONTHS.	DECLINATION CONSTANTS. Mean magnetic collimation.	H. F. CONSTANTS. MEAN VALUES OF P'S. P_1's	P_2's	Accepted value of $P_{1 \cdot 2}$	Accepted value of $P_{2 \cdot 2}$	Mean value of "m"	Accepted value of "m"	REMARKS.
	′ ″							
January . .	—1 : 17	8·60	9·34	8·54 throughout.	9·46 throughout.	896·05 (1) 895·80 (2)	896·05 ...	(1) From 1st January to 15th January. (2 From 19th January to 29th January.
February . .	: 4	8·49	9·28			895·69 (3)	895·69	(3) From 2nd February to 1st March.
March . . .	: 16	8·50	9·46			895·45 (4)	895·45	(4) From 3rd March to 9th April.
April . . .	: 11	8·64	9·49			895·21 (5)	895·21	(5) From 12th April to 5th May.
May . . .	: 8	8·54	9·37			895·01 (6) 894·79 (7)	895·01 ...	(6) From 7th to 21st May. (7) From 24th May to 7th June.
June . . .	: 8	8·62	9·30			894·68 (8)	894·68	(8) From 9th to 25th June.
July . . .	: 3	8·51	9·53			394·56 (9)	894·56	(9) From 28th June to 16th August.
August . . .	: 1	8·57	9·55			...		
September . .	: 1	8·53	9·64			894·23 (10) 894·04 (11)	894·23 ...	(10) From 18th August to 22nd September. (11) From 24th September to 11th October.
October. . .	: 7	8·53	9·49			893·83 (12)	893·83	(12) From 13th to 2[illegible]th October.
November . .	0 : 52	8·45	9·58			893·38 (13) 893·22 (14)	893·38 ...	(13) From 22nd October to 22nd November. 14) From 24th to 30th November.
December . .	variable	8·53	9·50			893·03 (15) 892·76 (16)	893·03 ...	(15) From 2nd to 20th December. (16) From 24th to 31st December.

3. *Mean Base Line values.*—The table below gives the accepted Base Line of the H. F. and Declination magnetographs, used in computing the monthly values.

The observed Declination base lines showed considerable variation and were rejected for the reasons given in the report for 1909-10.

During the inspection of the officer in charge in December 1910, it was found that the torsion tube was not rigidly connected with the magnet box, owing to shake in the brass bush through which the connection is made. There was thus liability to observational and azimuthal errors sufficient to account for the variations in magnetic collimation and base line values. This defect was remedied and the base line values have since been satisfactory.

The Horizontal Force observations were not affected; the observatory instrument is of the Kew pattern in which different magnet boxes are used for declination and deflection observations.

Abstract of Base Line value of the Magnetographs in 1910.

MONTHS, 1910.	DECLINATION. Mean observed value of Base line.	DECLINATION. Base line accepted.	DECLINATION. REMARKS.	HORIZONTAL FORCE. Mean observed value of Base line.	HORIZONTAL FORCE. Accepted value of Base line.	HORIZONTAL FORCE. REMARKS.
		° ′				
January	Observed base lines varying from − 0° : 9′·1 to −0° : 3′·2.	−0 : 9·1	For the reasons for which the observed Base lines were rejected—*See* report for 1909-10.	·38448	The accepted values are the same as the observed.	
February		: 9·1		·38448		
March		: 9·1		·38448		Up to 17th.
				·38486		From 18th March to 9th April.
April		: 9·1		·38486		Up to 9th.
				·38506		From 13th April.
May		: 9·1		·38506		To 22nd May.
				·38503		From 23rd May.
June		: 9·1		·38503		To 7th June.
				·38502		8th to 26th June.
				·38501		From 27th June.
July		: 9·1		·38501		
August		: 9·1		·38501		To 16th August.
				·38499		From 17th (interpolated) to 31st.
September		: 9·1		·38496		To 22nd September.
				·38493		From 23rd September to 11th October.
October		: 9·1		·38495		To 11th October.
				·38490		From 12th October to 22nd November.
November		: 9·1		·38490		To 22nd November.
				·38496		From 23rd November to 31st December.
December		: 9·1		·38496		

4. *Scale values and temperature range.*—The mean scale values in 1910 are as follows :—

H. F.	5·43γ	for an ordinate of $\frac{1}{25}''$.
Declination	1·04 minutes	
V. F.	4·46γ to 5·19γ	

The mean temperature of the observatory was 89°·0 F. with maximum and mininum mean monthly values of 89°·2 F. and 88°·7 F.

5. *Secular changes, 1909-10.*—The following table gives the mean monthly values of the magnetic elements and the secular change for the period 1909-10.

Secular changes at Toungoo in 1909-10.

MONTHS.	HORIZONTAL FORCE ·38000 C. G. S. +			DECLINATION E. 0° +			DIP N. 23° +			VERTICAL FORCE. ·16000 C. G. S. +			REMARKS.
	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January . . .	747	782	+35	32·2	27·3	—4·9	1·0	1·6	+0·6	460	483	+23	
February . . .	759	783	24	31·9	26·9	5·0	0·5	2·0	+1·5	458	489	31	
March . . .	754	793	39	31·5	26·6	4·9	1·2	1·8	+0·6	465	491	26	
April . . .	776	788	12	31·1	25·9	5·2	0·6	2·6	+2·0	467	499	32	
May	774	796	22	30·5	25·6	4·9	1·4	2·4	+1·0	477	500	23	
June . . .	777	797	20	30·4	25·3	5·1	1·7	2·0	+0·3	483	495	12	
July	777	809	32	29·8	24·8	5·0	1·0	2·1	+1·1	472	502	30	
August . . .	780	809	29	29·3	24·1	5·2	1·4	2·3	+0·9	479	504	25	
September . .	766	811	45	28·8	23·6	5·2	1·9	2·1	+0·2	481	501	20	
October . . .	735	799	64	28·6	23·4	5·2	3·0	2·2*	—0·8	482	498	16	* Mean observed values of Dip.
November . .	774	815	41	28·1	22·9	5·2	1·7	1·8	+0·1	481	500	19	,,
December . . .	776	834	58	27·5	22·3	5·2	2·2	2·2	0·0	489	513	24	,,
Means . . .	766	801	+35	30·0	24·9	—5·1	1·5	2·1	+0·6	475	498	+23	

D—KODAIKANAL OBSERVATORY.

1. *General Remarks on working.*—Surveyor Ramaswami Iyengar was in charge throughout the year.

Thanks are due to the Director, Solar Physics Observatory, for his cordial assistance in all matters connected with the magnetic work.

The instruments worked satisfactorily throughout the year, except that as in other observatories it was necessary to adjust the balance of the V. F. magnet on several occasions.

2. *H. F. and declination constants.*—The table below gives the mean observed monthly values of magnetic collimation, $P_{1\cdot 2}$ and $P_{2\cdot 3}$ and magnetic moment: the accepted values of $P_{1\cdot 2}$ and "m_0" are those used for computing the monthly mean base lines.

It will be noticed that the observed values of "m_0" show both sudden and gradual decreases of "m_0," which have been disregarded in deriving the accepted value: this conclusion was arrived at after consideration of the resulting monthly mean values of H. F. and independently of the investigation of "personal error" referred to elsewhere in this report, which has not yet been completed.

Mean values of the constants of the Magnetometer No. 16 in 1910.

MONTHS.	DECLINATION CONSTANTS.	H. F. CONSTANTS.						REMARKS.
	Mean magnetic collimation.	MEAN VALUE OF P'S.				Mean value of "m."	Accepted value of "m."	
		$P_{1\cdot2}$.	$P_{2\cdot3}$.	Accepted value of $P_{1\cdot2}$.	Accepted value of $P_{2\cdot3}$.			
	′ ″							
January	– 2 : 37	6·90	9·13	6·92 throughout.	9·05 throughout.	918·76 (1)	918·76 throughout.	(1) From 5th January to 26th February.
February	: 32	6·97	9·25			918·76		
March	: 33	6·92	8·92			918·64 (2)		(2) From 1st March to 21st May.
April	: 35	7·07	9·08			918·64		
May	: 32	7·00	8·98			918·64		
June	: 36	6·97	9·05			918·37(3)		(3) From 24th May to 4th August.
July	: 35	6·93	9·12			918·37		
August	: 38	6·75	9·20			918·21 (4)		(4) From 6th to 11th August.
						917·97 (5)		(5) From 13th to 25th August.
September	: 37	6·84	9·14			917·69(6)		(6) From 27th August to 31st December.
October	: 36	6·87	8·82			917·69		
November	: 29	6·92	8·86			917·69		
December	: 32	6·87	9·07			917·69		

3. ***Mean Base Line values.***—The table below gives the mean monthly observed and accepted values of the Declination and H. F. base lines: the accepted values are those used in computing the monthly mean values.

Abstract of Base Line value of Magnetographs in 1910.

MONTHS 1910.	DECLINATION.			HORIZONTAL FORCE.		
	Mean observed value of base line.	Base line accepted.	REMARKS.	Mean observed value of base line.	Base line accepted.	REMARKS.
	° ′	° ′				
January	1: 32·7	1: 32·7		·36954	·36954	
February	1: 32·9	1: 32·9		·36950	·36950	
March	1: 32·8	1: 32·8		·36949	·36949	
April	1: 33·0	1: 33·0		·36950	·36950	
May	1: 33·1	1: 33·1		·36952	·36952	
June	1: 33·2	1: 33·2		·36950	·36950	
July	1: 33·0	1: 33·0		·36947	·36947	
August	1: 32·9	1: 32·9		·36946	·36946	
September	1: 32·7	1: 32·7		·36946	·36946	
October	1: 32·7	1: 32·7		·36946	·36946	
November	1: 33·1	1: 33·1		·36949	·36949	
December	1: 32·8	1: 32·8		·36949	·36949	

4. *Scale values and temperature range.*—The mean scale values for the magnetographs during 1910 are as follows :—

H. F.	6·14γ		
Declination	1·03	minutes	for an ordinate of $\frac{1}{25}''$.
V. F.	5·90γ to 6·69γ		

The mean temperature of the magnetograph room for the year was 18°·9 C with maximum and minimum monthly mean values of 19°·1 C and 18°·7 C.

The selected mean temperature is 19°·0 C.

5. *Secular changes, 1909-10.*—The table below gives the mean monthly values of the magnetic elements for 1909-10 with the secular change deduced during the interval :—

Secular changes at Kodaikānal in 1909-10.

MONTHS.	HORIZONTAL FORCE ·37000 C. G. S. +			DECLINATION W. 0° +			DIP N. 3° +			VERTICAL FORCE ·01000 C. G. S.+			REMARKS.
	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	1909.	1910.	Secular change.	
	γ	γ	γ	′	′	′	′	′	′	γ	γ	γ	
January . . .	442	481	+39	47·9	52·5	+4·6	36·1	41·8	+5·7	356	422	+66	
February . . .	450	469	19	48·2	53·0	4·8	36·9	43·1	6·2	365	435	70	
March . . .	450	480	30	48·5	53·3	4·8	36·8	43·4	6·6	365	439	74	
April . . .	466	473	7	49·3	54·2	4·9	38·3	43·7	5·4	382	442	60	
May	463	483	20	49·8	54·7	4·9	38·5	44·1	5·6	385	446	61	
June . . .	464	482	18	50·1	55·0	4·9	39·0	45·2	6·2	389	458	69	
July	466	484	18	50·3	55·3	5·0	39·9	45·9	6·0	400	466	66	
August . . .	474	486	12	50·7	55·7	5·0	39·9	46·4	6·5	401	472	71	
September . .	467	494	27	50·9	55·9	5·0	40·1	46·7	6·6	402	476	74	
October . . .	439	479	40	51·3	56·2	4·9	40·3	47·2	6·9	402	481	79	
November . .	460	492	32	51·7	57·2	5·5	41·5	47·6	6·1	417	486	69	
December . .	463	511	48	52·1	57·4	5·3	42·1	47·8	5·7	423	489	66	
Means . . .	459	485	+26	50·1	55·0	+5·0	39·1	45·2	+6·1	391	459	+69	

III.—TABLES OF RESULTS.

INDEX TO TABLES.

A. Approximate values of the magnetic elements at stations of observation during 1910-11.
B. Mean values of the magnetic elements at the observatories for 1910.
C. Classification of curves and dates of magnetic disturbances in 1910.
D. Tables of results at Dehra Dūn.
E. „ „ Barrackpore.
F. „ „ Toungoo.
G. „ „ Kodaikānal.

For each observatory the following tables are given :—

1. Hourly means corrected for temperature, of Declination, Horizontal Force, Vertical Force and dip from 5 selected quiet days per month.
2. Diurnal inequality of each deduced from 1.

A.—Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11.

FIELD STATIONS.

Serial No.	Name of station.	Latitude. ° ′ ″	Longitude. ° ′ ″	Dip. ° ′	Declination. ° ′	Horizontal force. C. G. S.	REMARKS.
1331	Mussoorie	30 27 40	78 5 10	44 12	E 2 35	0·3312	H is derived from mean "m_0" throughout.
1332	Port Anson	12 18 0	92 43 0	7 57	W 0 15	·3952	
1333	Port Andaman	12 48 10	92 40 20	9 14	„ 0 12	·3949	
1334	Paget Island	13 25 50	92 50 0	10 44	„ 0 10	·3952	
1335	Mysore Mines (surface).	12 55 30	78 15 40	9 55	„ 0 54	·3815	
	Mysore Mines (underground).	12 55 30	78 15 40	9 56	„ 1 59	·3820	
1336	Jhala	31 1 50	78 42 50	45 4	E 2 38	·3284	
1337	Barahat	30 44 30	78 27 10	44 44	„ 2 38	·3291	
1338	Barmer	25 44 40	71 26 40	36 31	„ 1 50	·3436	
1339	Dhoda	32 9 50	74 41 50	46 44	„ 3 11	·3192	
1340	Behāri	33 23 20	73 43 50	48 23	„ 3 38	·3122	
1341	Murree (Sunny Bank).	33 55 10	73 23 20	49 6	„ 3 49	·3093	
1342	Muzaffarābād	34 22 10	73 27 40	49 45	„ 3 55	·3074	
1343	Uri	34 5 0	74 2 50	49 18	„ 3 57	·3099	
1344	Shalura	34 29 30	74 7 40	49 58	„ 4 0	·3066	
1345	Gurais	34 38 0	74 51 50	50 14	„ 4 0	·3056	
1346	Hīrpur	33 40 50	74 43 0	48 56	„ 3 26	·3119	
1347	Islāmābād	33 43 50	75 8 50	48 58	„ 3 43	·3119	
1348	Inshin	33 48 30	75 33 40	49 7	„ 3 50	·3116	
1349	Sof	33 37 0	75 17 40	48 46	„ 3 37	·3131	
1350	Banihal	33 26 20	75 12 0	48 38	„ 3 41	·3136	
1351	Ramban	33 13 30	75 14 40	48 13	„ 3 40	·3157	
1352	Udhampur	32 55 20	75 7 30	47 51	„ 3 38	·3166	
1353	Poni	33 4 50	74 41 50	47 44	„ 3 50	·3161	
1354	Thana Mandi	33 32 40	74 22 0	48 13	„ 3 49	·3167	
1355	Changas Sarai	33 14 40	74 15 50	48 22	„ 3 22	·3132	
1356	Bhimbar	32 58 20	74 4 50	47 51	„ 3 26	·3149	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11—continued.

OLD STATIONS RE-OBSERVED.

Serial No.	Name of Stations.	Latitude.			Longitude			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	′	″	°	′	″	°	′		°	′	C. G. S.	
46	Ruk Junction .	27	48	20	68	30	20	39	40	E.	2	3	0·3349	H is derived from mean m_0 throughout.
71	Lahore . .	31	35	50	74	18	50	46	14	"	2	56	0·3208	
88	Peshāwar . .	34	0	40	71	33	40	49	5	"	3	49	0·3083	
92	Kundian . .	32	27	30	71	28	20	47	49	"	3	26	0·3099	
105	Sachīn . .	21	4	40	72	52	40	27	42	"	3	23	0·3655	
124	Bikaner . .	28	0	40	73	18	50	40	14	"	2	1	0·3387	
130	Ajmer . .	26	27	30	74	38	30	37	32	"	1	56	0·3467	
134	Mirpur Khās .	25	31	40	69	0	40	35	50	"	1	51	0·3448	
139	Viramgām .	23	8	10	72	3	30	31	33	"	1	6	0·3567	
172	Dhond . .	18	28	0	74	35	10	22	28	"	0	22	0·3711	
175	Hotgi . .	17	33	40	76	0	20	20	35	"	0	8	0·3752	
181	Guntakal . .	15	10	20	77	22	40	15	30	W.	0	26	0·3800	
186	Arkonum . .	13	4	30	79	40	20	10	26	"	0	57	0·3854	
187	Perambūr . .	13	6	40	80	15	0	10	34	"	0	49	0·3840	
199	Cannanore . .	11	52	30	75	22	0	8	34	"	1	21	0·3807	
207	Birur . .	13	35	50	75	58	10	11	47	"	0	40	0·3795	
216	Mirāj . .	16	49	10	74	38	10	19	37	"	0	9	0·3769	
223	Manmād . .	20	14	40	74	26	20	26	22	E.	1	8	0·3620	
232	Delhi . .	28	40	20	77	14	20	41	23	"	1	59	0·3401	
283	Sirsā . .	29	32	10	75	2	40	42	37	"	2	34	0·3337	
328(*a*)	Tinnevelly . .	8	44	0	77	42	30	0	55	W.	1	39	0·3796	
332	Mandapam . .	9	16	50	79	8	30	1	37	"	1	26	0·3823	
337	Tanjore . .	10	46	40	79	8	20	4	44	"	1	22	0·3825	
375	Parbhani . .	19	15	20	76	46	50	24	51	E	0	39	0·3705	
384	Bezwāda . .	16	31	0	80	36	50	17	52	W.	0	33	0·3821	
481	Allāhābād . .	25	27	30	81	49	20	35	41	E.	1	17	0·3583	
483	Manikpur . .	25	3	10	81	5	20	35	14	"	1	14	0·3590	
489	Monghyr . .	25	23	10	83	27	50	35	43	"	1	11	0·3630	
500	Sini . .	22	47	0	85	56	50	30	32	"	0	50	0·3742	
504	Rānīganj . .	23	35	30	87	7	30	32	11	"	0	55	0 3706	
505	Katrasgarh . .	23	48	0	86	18	0	32	46	"	0	58	0·3678	
506	Gīrīdīh . .	24	10	50	86	19	20	33	20	"	0	57	0·3665	
512	Buxar . .	25	33	30	83	57	40	36	6	"	3	9	0·3625	
518	Katarnian Ghāt .	28	19	50	81	7	50	40	48	"	2	0	0·3450	
527	Chāpra . .	25	48	10	84	43	20	36	57	"	0	22	0·3597	
530	Bettiah . .	26	48	50	84	31	30	38	19	"	1	36	0·3546	
544	Bārāsn . .	25	5	30	76	30	30	35	31	"	1	21	0·3527	
545	Bina . . .	24	10	50	78	11	0	33	15	"	1	11	0·3672	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11—continued.

OLD STATIONS RE-OBSERVED—*concluded.*

Serial No.	Name of Stations.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force C. G. S.	REMARKS.
557	Indore	22	42	10	75	52	40	30	52	E.	0	45	0·3680	H is derived from mean "m_0" throughout.
573	Cawnpore	26	27	0	80	21	0	37	38	„	1	40	0·3532	
598	Kāthgodām	29	15	20	79	32	50	42	25	„	2	17	0·3381	
692	Balasore	21	30	30	86	54	40	28	19	„	0	27	0·3763	
699	Berhampur (Ganjām)	19	18	10	84	48	40	23	53	„	0	7	0·3807	
710	Cumbum	15	35	50	79	6	40	16	20	W.	0	51	0·3816	
746	Chānda	19	57	50	79	17	40	25	20	E.	0	24	0·3744	
765	Raipur	21	15	50	81	38	20	28	12	„	0	35	0·3709	
779	Amraoti	20	55	30	77	45	50	27	46	„	0	14	0·3647	
820	Mymensingh	24	46	0	90	23	40	34	47	„	1	5	0·3670	
831	Sāntāhār	24	48	10	88	59	20	34	39	„	1	7	0·3678	
860	Lumding	25	44	50	93	10	40	36	24	„	1	3	0·3667	
873	Jāmtāra	23	38	40	86	48	50	33	14	„	0	59	0·3666	
874	Dumka	24	15	50	87	14	40	33	38	„	1	12	0·3665	
960	Dumraon	25	34	40	84	7	30	36	17	„	0	5	0·3542	
997(*a*)	Balliā	25	45	10	84	10	10	37	8	„	0	53	0·3546	
1256(*a*)	Srīnagar	34	3	50	74	50	30	49	27	„	3	51	0·30[illegible]9	
1257(*a*)	Sonamarg	34	18	30	75	18	30	49	43	„	3	49	0·3084	

DETAIL SURVEY STATIONS.

Serial No.	Name of Stations.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force C. G. S.	REMARKS.
194 D	Jorapokhar	23	41	50	86	25	0	32	41	E.	1	0	0·3684	H is derived from mean "m_0" throughout.
195 D	Barari (Underground).	23	41	30	86	26	0	32	49		...		0·3688	
196 D	Dhanbaid	23	48	10	86	26	10	32	49	E.	1	6	0·3679	
197 D	Jogta	23	47	30	86	20	0	32	48	„	0	56	0·3672	
198 D	Do. (Underground).	23	47	30	86	20	10	32	44	„	0	59	0·3674	
199 D	Matāri	23	50	50	86	15	10	32	46	„	1	2	0·3675	
200 D	Sadhobād	23	52	50	86	22	0	33	14	„	1	1	0·3662	
201 D	Sitalpur	23	59	0	86	21	40	33	2	„	1	6	0·3676	
202 D	Tundi	23	58	30	86	27	10	33	0	„	1	7	0·3675	
203 D	Noaland	23	53	0	86	33	20	32	58	„	0	48	0·3668	
204 D	Obcharia	23	49	30	86	42	20	33	2	„	1	3	0·3674	
205 D	Agiarkund	23	45	10	86	46	10	32	47	„	1	3	0·3695	
206 D	Sitalpur	23	44	0	86	35	40	32	56	„	0	56	0·2697	
207 D	Koriatand	23	40	10	86	26	40	32	37	„	0	57	0·3693	
208 D	Chiliwan	23	37	30	86	33	0	32	27	„	0	54	0·3682	
209 D	Raghunāthpur	23	32	50	86	40	20	32	37	„	0	53	0·3670	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11—continued.

Detail Survey Stations—*continued.*

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.		Horizontal Force.	Remarks.
		°	′	″	°	′	″	°	′	°	′	C. G. S.	
210D	Benāgaria . .	23	31	50	86	48	50	32	6	E. 0	52	0·3690	H is derived from mean "m₀" throughout.
211D	Notandih . .	23	38	30	86	46	30	32	22	„ 0	50	0·3702	
212D	Deshergarh . .		...			...		...		„ 0	57	...	
212D (a)	Deshargarh (Under-ground).	23	41	40	86	50	10	32	26	...		0·3704	
213D	Dhadka .	23	42	40	86	58	50	32	29	E. 0	59	0·3703	
214D	Anchra . .	23	48	10	86	54	10	33	0	„ 1	2	0·3684	
215D	Nandi . . .	23	43	10	87	6	0	...		„ 1	1	...	
215D (a)	Do. (Under-ground).	23	43	10	87	6	0	32	38	„ 1	4	0·3707	
216D	Ranjitpur . .	23	32	30	86	59	0	32	26	„ 0	58	0·3664	
217D	Doolluvepur .	23	28	10	87	7	30	31	58	„ 0	53	0·3684	
218D	Barjorah . .	23	25	30	87	17	20	32	6	„ 0	55	0·3694	
219D	Kaksa . . .	23	27	20	87	27	20	32	0	„ 0	55	0·3701	
220D	Bishtopur . .	23	37	20	87	24	20	32	29	„ 0	59	0·3700	
221D	Bheringee .	23	33	0	87	16	40	32	12	„ 0	57	0·3699	
222D	Sunpur . .	23	41	50	87	13	40	32	35	„ 0	52	0·3714	
223D	Dubrajpur . .	23	47	20	87	22	20	33	3	„ 0	52	0 3699	
224D	Palasboni . .	23	51	0	87	13	50	33	15	„ 0	59	0·3688	
225D	Korurreeya . .	23	57	30	87	21	50	33	19	„ 0	56	0·3673	
226D	Rannabandh . .	24	4	50	87	28	40	33	15	„ 1	3	0·3684	
227D	Mohulpaharee .	24	13	50	87	25	50	34	6	„ 0	56	0·3645	
228D	Masanjore . .	24	7	0	87	18	40	33	49	„ 1	20	0·3658	
229D	Baboopur . .	24	1	20	87	9	0	33	21	„ 1	1	0·3662	
230D	Siriskundi .	23	52	20	87	5	20	33	13	„ 1	1	0·3675	
231D	Kussumdhi . .	23	55	40	86	56	40	33	13	„ 1	4	0·3656	
232D	Jokunda . .	24	4	50	86	59	10	33	25	„ 1	2	0·3649	
233D	Oojhadih . .	24	10	40	87	5	40	33	14	„ 1	26	0·3678	
234D	Jumooa .	24	13	40	86	56	50	33	25	„ 1	4	0·3672	
235D	Rootura . .	24	5	50	86	49	50	33	28	„ 1	9	0·3655	
236D	Bamungaon .	24	14	20	86	48	40	33	27	„ 1	13	0·3656	
237D	Lālgarh . .	24	15	10	86	39	50	33	37	„ 1	12	0·3656	
238D	Sujlapur . .	24	11	10	86	31	40	33	28	„ 1	4	0·3667	
239D	Jynathpur . .	24	7	10	86	40	10	33	26	„ 1	6	0·3656	
240D	Sukjora . .	23	57	0	86	38	50	32	59	„ 0	54	0·3679	
241D	Cherodeeh . .	24	2	20	86	31	30	33	32	„ 1	4	0·3650	
242D	Pindatand . .	24	6	20	86	24	40	33	28	„ 1	1	0·3644	
243D	Docmureea . .	24	3	10	86	15	30	33	51	„ 1	3	0·3638	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11—continued.

DETAIL SURVEY STATIONS—*concluded.*

Serial No.	Name of Stations.	Latitude.			Longitude.			Dip.		Declination.			Horizontal Force.	REMARKS.
		°	′	″	°	′	″	°	′		°	′	C. G. S.	
244D	Mudkutta . .	23	56	30	86	12	30	33	27	E.	0	45	0·3624	H is derived from mean "m_0" throughout.
245D	Rungamuttee .	23	58	20	86	2	50	33	7	"	1	7	0·3685	
246D	Chausā . .	25	31	10	83	54	10	35	56	"	1	10	0·3584	
247D	Kiritpura . .	25	33	0	83	56	20	35	47	"	2	24	0·3577	
248D	Muhudeb . .	25	31	40	84	1	10	37	10	"	3	10	0·3609	
249D	Busoodhur . .	25	27	20	84	3	0	37	47	"	1	53	0·3623	
250D	Uhronlee . .	25	25	40	84	0	30	38	1	"	2	32	0·3553	
251D	Chunda . .	25	34	50	84	4	20	37	49	"	0	1	0·3530	
252D	Manikpur . .	25	40	20	84	5	20	36	51	"	0	29	0·3589	
253D	Rājapur . .	25	40	50	84	9	40	36	31	"	0	50	0·3575	
254D	Uruk . .	25	37	0	84	12	40	36	16	"	1	11	0·3583	
255D	Reheea . .	25	33	0	84	13	10	36	15	"	1	13	0·3561	
256D	Koorand . .	25	28	40	84	11	0	36	49	"	0	33	0·3566	
257D	Nainee . .	25	50	20	84	42	50	37	23	"	0	45	0·3563	
258D	Mubārakpur . .	25	46	30	84	40	30	37	22	"	0	39	0·3606	
259D	Telpa . .	25	47	10	84	45	40	36	36	"	0	42	0·3595	
260D	Mashrak . .	26	6	0	84	48	50	36	39	"	1	19	0·3568	
261D	Paterhi . .	25	54	40	84	48	20	37	33	"	1	13	0·3528	
262D	Reoti . . .	25	49	40	84	22	50	36	42	"	1	56	0·3578	
263D	Phephna . .	25	45	50	84	3	20	37	34	"	1	7	0·3512	
264D	Luthoodeeh . .	25	42	10	83	52	50	36	0	"	1	51	0·35[illegible]6	
265D	Bureneea . .	25	37	10	83	55	20	36	27	"	1	42	0·3578	
266D	Behea . .	25	33	0	84	27	40	36	6	"	1	27	0·3589	
267D	Piaro . . .	25	19	40	84	24	0	35	38	"	0	59	0·3617	
268D	Bikramganj .	25	13	0	84	15	0	35	26	"	1	6	0·3623	
269D	Dinara . .	25	15	40	84	3	20	35	31	"	1	26	0·3627	
270D	Manoharpur .	25	21	0	83	54	20	35	37	"	1	32	0·3616	
271D	Parusthooa . .	25	13	10	83	48	30	35	25	"	1	25	0·3603	
272D	Mohanea . .	25	9	50	83	37	30	35	19	"	1	8	0·3599	
273D	Sasarām . .	24	57	10	84	0	20	34	52	"	1	3	0·3604	

REPEAT STATIONS.

I	Udaipur .	24	35	33	73	41	57	34	10	E.	1	18	0·3521	H is derived from mean "m_0" throughout.
II	Karāchi . .	24	49	50	67	2	2	34	38	"	1	42	·3446	
III	Quetta . .	30	11	52	67	0	20	43	30	"	3	7	·3215	
IV	Bahāwalpur .	29	23	27	71	40	27	42	26	"	2	49	·3306	
VI	Bharatpur .	27	13	27	77	29	28	38	59	"	1	52	·3452	

Abstract showing approximate magnetic values at stations observed at by No. 18 Party during season 1910-11—concluded.

REPEAT STATIONS—*concluded.*

Serial No.	Name of Stations.	Latitude. °	′	″	Longitude. °	′	″	Dip. °	′	Declination.	°	′	Horizontal Force. C. G. S.	REMARKS.
VII	Bangalore .	12	59	35	77	35	58	10	7	W.	0	51	·3818	H is derived from mean "m₀" throughout.
VIII	Dhārwār .	15	27	26	74	59	35	15	44	,,	0	23	·3766	
IX	Porbandar .	21	38	20	69	37	6	29	8	E.	1	11	·3588	
X	Fyzābād . .	26	47	27	82	7	40	38	12	,,	1	38	·3525	
XI	Sambalpur .	21	28	3	83	58	24	28	8	,,	0	36	·3730	
XII	Waltair . .	17	42	57	83	19	1	21	27	,,	0	0	·3789	
XIII	Darjeeling .	26	59	49	88	16	39	38	31	,,	1	21	·3568	
XIV	Gayā . .	24	46	80	84	58	54	34	31	,,	0	58	·3661	
XV	Secunderābād .	17	27	11	78	29	16	20	26	,,	0	6	·3792	
XVI	Bhusāval . .	21	2	46	75	47	18	27	20	,,	0	42	·3677	
XVII	Jubbulpore .	23	8	57	79	56	44	31	21	,,	0	54	·3643	
XVIII	Tavoy . .	14	4	50	98	12	30	12	11	,,	0	20	·3963	
XIX	Lashio . .	22	56	47	97	44	40	31	21	,,	0	33	·3768	
XX	Akyab . .	20	7	53	92	53	18	25	33	,,	0	30	·3839	
XXI	Silchar or Cāchār	24	49	43	92	47	21	34	48	,,	0	57	·3692	
XXII	Dibrugarh .	27	29	24	94	55	40	39	36	,,	1	2	·3584	
XXIII	Port Blair .	11	39	10	92	43	13	6	20	W.	0	15	·3963	

NOTE.—The above values of Dip, Declination and Horizontal Force are uncorrected for secular change, diurnal variation, instrumental differences, etc., and are to be considered preliminary values only.

Where blanks occur, values have already been found during previous field seasons, or the observations have not been completed.

All Longitudes are referable to that of Madras Observatory taken at the value 80° 14′ 54″ East from Greenwich.

B.—Mean values of Magnetic Elements at Observatories during 1910.

Observatories.	Latitude. °	′	″	Longitude. °	′	″	Dip. ° ′	Declination. ° ′	Horizontal Force.	Vertical Force.
Dehra Dūn . .	30	19	19	78	3	19	N. 48 54·8	E 2 31·9	·33257	·32019
Barrackpore . .	22	46	29	88	21	39	N. 30 42·2	E 0 55·5	·37329	·22168
Toungoo . . .	18	55	24	96	27	3	N. 23 2·1	E 0 24·9	·38801	·16498
Kodaikānal . .	10	13	50	77	27	46	N. 3 45 2	W 0 55·0	·37485	·02459

C.—*Dates of magnetic disturbances, 1910.*

Station		°	′	″
D=Dehra Dun	Lat.	30	19	19
	Long.	78	3	19
B=Barrackpore	Lat.	22	46	29
	Long.	88	21	39
T=Toungoo	Lat.	18	55	45
	Long.	96	27	3
K=Kodaikanal	Lat.	10	13	50
	Long.	77	27	46

Date.	January.				February.				March.				April.				May.				June.			
1910	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K
1	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C
2	C	C	C	C	S	S	S	C	C	C	C	C	S	S	S	S	C	C	C	C	C	C	C	C
3	C	C	C	C	S	S	S	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
4	C	C	C	C	C	C	C	C	—	C	C	C	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)
5	C	C	C	C	C	C	C	C	S	C	C	C	C	C	C	C	C	C	C	C	—	C	C	C
6	C	C	C	C	(C)	(C)	(C)	(C)	S	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	—	C	C	C
7	C	C	C	C	C	C	C	C	S	C	S	S	C	C	C	C	C	C	C	C	—	C	C	C
8	(C)	(C)	(C)	(C)	C	C	C	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S
9	S	S	S	C	S	S	S	S	C	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S
10	S	S	S	C	C	C	C	C	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	S	C	C	C
11	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
12	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	C	C	C	C
13	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	C	S	S	S	S	(C)	(C)	(C)	(C)
14	S	S	S	S	M	M	S	S	S	S	S	S	C	C	C	C	S	S	S	S	—	C	C	C
15	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	C	C	C	C	S	C	S	S	—	C	C	C
16	C	C	C	—	S	S	S	S	S	S	S	S	C	C	C	C	C	C	C	C	—	C	C	C
17	M	M	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	—	C	C	C
18	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	—	C	C	C
19	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	S	S	S	S	—	C	C	C
20	(C)	(C)	(C)	(C)	M	S	S	S	S	C	C	C	(C)	(C)	(C)	(C)	S	S	C	C	—	S	S	S
21	C	C	C	C	S	S	S	S	S	S	C	C	C	C	C	C	C	C	C	C	—	M	M	S
22	S	S	C	C	S	S	S	C	S	C	C	C	C	C	C	C	C	C	C	C	—	S	S	S
23	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	S	S	S	S	(C)	(C)	(C)	(C)	—	C	C	C
24	M	M	M	S	S	S	S	S	C	C	C	C	S	S	S	C	S	S	S	S	(C)	(C)	(C)	(C)
25	M	M	M	S	S	S	S	C	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	S	C	C	C
26	S	S	S	S	S	S	S	S	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	—	C	C	C
27	S	S	S	C	(C)	(C)	(C)	(C)	C	C	C	C	M	M	M	M	C	C	C	C	—	C	C	C
28	C	C	C	C	S	C	C	C	G	G	M	S	S	S	S	S	S	C	C	C	C	C	C	—
29	C	C	C	C	...	...	...	...	M	M	S	S	S	S	S	S	C	C	C	C	S	C	C	—
30	C	C	C	C	...	...	...	...	S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C
31	(C)	(C)	(C)	(C)	...	...	...	...	S	S	S	S	...	...	...	...	C	C	C	C	...	...	...	...
C	19	19	20	22	13	14	14	18	15	21	21	20	17	17	17	19	20	22	22	22	10	25	25	23
S	9	9	9	8	13	13	14	10	13	8	9	11	12	12	12	10	11	9	9	9	5	4	4	5
M	3	3	2	...	2	1	...	...	1	1	1	...	1	1	1	1	...	...	...	...	...	1	1	...
G	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trace lost	...	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	15	...	...	2

Date.	July.				August.				September.				October.				November.				December.				Remarks.
1910	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	D	B	T	K	
1	C	C	C	C	S	S	S	S	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	S	S	S	S	
2	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
3	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	C	
4	C	C	C	—	S	S	S	S	C	C	C	C	S	S	S	S	S	S	S	S	S	C	C	C	
5	M	M	M	M	—	S	S	S	C	C	C	C	S	S	S	C	S	S	S	C	S	S	S	C	
6	S	S	S	S	—	C	C	C	S	S	S	C	M	M	S	S	S	S	S	C	—	S	S	S	
7	—	S	S	S	C	C	C	C	—	S	S	S	S	S	S	S	—	S	S	S	—	S	S	S	
8	S	S	S	S	—	—	C	C	—	C	C	C	S	C	C	C	S	S	S	S	S	S	S	C	
9	S	S	S	C	—	C	C	C	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	
10	S	S	S	S	M	M	M	M	S	S	—	S	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	
11	C	C	C	C	S	S	S	S	(S)	(S)	(S)	(S)	S	S	C	C	S	S	S	S	(C)	(C)	(C)	(C)	
12	(C)	(C)	(C)	(C)	C	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	(C)	(C)	(C)	(C)	
13	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	S	S	S	
14	C	C	C	C	S	S	S	S	S	S	S	S	S	S	S	C	—	S	S	S	S	S	—	S	
15	S	S	C	C	S	S	S	S	S	S	S	S	(S)	(C)	(C)	(C)	—	C	C	S	S	S	S	S	
16	S	C	C	C	(C)	(C)	(C)	(C)	S	S	S	S	C	C	C	C	S	S	S	S	C	—	C	C	
17	(C)	(C)	(C)	(C)	C	C	C	C	C	C	C	C	C	C	C	C	S	S	S	S	C	C	—	C	
18	(C)	(C)	(C)	(C)	S	S	S	S	(C)	(C)	(C)	(C)	C	C	C	C	M	M	M	S	(C)	(C)	(C)	(C)	
19	S	S	S	S	M	—	S	S	(C)	(C)	(C)	(C)	M	M	M	M	M	M	M	S	S	C	C	C	
20	C	C	S	S	—	—	S	S	S	S	S	S	S	S	S	S	C	C	C	C	S	C	C	C	
21	C	C	C	C	—	—	S	S	S	S	S	S	S	S	S	S	S	S	S	C	S	S	S	C	
22	S	S	S	C	—	G	G	—	S	S	S	S	S	S	S	S	S	S	S	C	S	S	S	S	
23	S	S	S	S	—	S	S	S	S	S	S	S	S	S	S	C	C	C	C	C	S	S	S	S	
24	S	S	S	S	—	S	S	S	S	S	S	C	S	S	S	C	(C)	(C)	(C)	(C)	C	C	C	C	
25	—	S	S	S	—	C	C	C	S	S	S	S	S	S	S	S	(S)	(S)	(S)	(C)	S	S	S	C	
26	S	S	S	S	—	C	C	C	S	S	S	S	S	S	S	S	S	S	S	S	C	C	C	C	
27	—	C.	C	C	(C)	(C)	(C)	(C)	S	S	S	S	S	S	S	S	S	C	C	C	(S)	(S)	(S)	(C)	
28	—	C	C	C	M	M	M	S	S	S	S	C	—	S	S	S	S	S	S	S	S	S	S	S	
29	M	M	M	M	S	S	S	S	G	G	M	M	S	S	S	C	S	S	S	S	M	S	S	S	
30	S	S	S	S	S	S	S	S	G	M	M	M	S	S	S	C	S	S	S	S	S	S	S	S	
31	C	C	C	C	S	S	S	S	...	...	...	...	C	C	C	C	...	...	...	...	C	C	C	C	
C	12	15	15	16	5	9	10	10	8	9	9	12	7	9	10	15	6	8	8	12	10	12	12	19	
S	13	14	14	12	12	15	18	19	18	19	18	16	21	20	20	15	19	20	20	18	18	18	17	12	
M	2	2	2	2	3	2	2	1	...	1	2	2	2	2	1	1	2	2	2	...	1	...	...	...	
G	...	...	...	...	...	1	1	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Trace lost	4	...	...	1	11	4	...	1	2	...	1	...	1	...	...	..	3	...	...	...	2	1	2	...	

( )=The selected quiet day. C=Calm. S=Slight. M=Moderate. G=Great. — =Trace lost.

D.—Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
	·33000 +												Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	262	260	262	260	261	262	264	268	**272**	271	267	262	262	262	261	261	263	**260**	263	263	262	262	262	261	262	263
February .	255	257	**254**	258	258	258	260	262	262	266	266	267	271	**274**	271	266	258	254	257	256	257	256	259	258	258	261
March .	260	264	263	262	262	265	264	262	262	266	269	271	277	281	**282**	276	270	266	263	261	261	**259**	261	262	265	266
October .	235	236	234	235	237	235	235	234	**238**	233	243	247	253	**257**	254	248	245	242	242	239	239	239	241	240	239	241
November .	236	**235**	241	240	239	240	242	246	249	252	250	254	**257**	[illegible]	248	245	243	241	238	238	237	239	239	237	238	243
December .	243	243	242	242	242	246	247	250	253	250	252	**261**	258	255	253	251	253	218	248	241	241	247	**238**	245	244	248
Means .	**248**	249	249	250	250	251	252	254	255	256	258	260	263	**264**	262	258	255	252	252	250	250	250	250	251	251	254
													Summer.													
April .	252	251	253	252	253	254	252	252	**249**	249	255	265	269	**271**	268	266	259	256	254	254	254	255	257	258	258	256
May .	264	263	263	264	264	264	264	**262**	263	266	274	288	**289**	288	284	276	270	267	267	266	266	268	267	267	270	270
June .	264	261	264	264	263	264	266	263	259	257	262	269	271	**276**	275	272	263	260	259	**256**	259	266	261	263	264	264
July .	268	266	267	267	265	267	269	267	266	266	268	273	279	**281**	281	277	271	267	265	**265**	266	268	267	269	272	269
August .	250	253	253	252	253	254	255	253	245	242	**239**	239	250	260	**264**	261	258	253	255	256	256	257	254	254	263	253
September .	260	260	256	255	257	257	255	249	239	**236**	239	243	255	260	263	**266**	264	263	259	258	255	257	258	258	262	255
Means .	260	259	259	259	259	260	260	258	254	**253**	256	263	269	**273**	273	270	264	261	260	259	259	262	261	262	265	261

Diurnal Inequality of the Horizontal Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−1	−3	−1	−3	−2	−1	+1	+5	+9	+8	+4	−1	−1	−1	−2	−2	0	−8	0	0	−1	−1	−1	−2	−1
February	−6	−4	−7	−3	−3	−3	−1	+1	+1	+5	+5	+6	+10	+13	+10	+5	−3	−7	−4	−5	−4	−5	−2	−3	−3
March	−6	−2	−3	−4	−4	−1	−2	−4	−4	0	+3	+5	+11	+15	+16	+10	+4	0	−3	−5	−5	−7	−5	−4	−1
October	−6	−5	−7	−6	−4	−6	−6	−7	−8	−8	+2	+6	+12	+16	+13	+7	+4	+1	+1	−2	−2	−2	0	−1	−2
November	−7	−8	−2	−3	−4	−3	−1	+3	+6	+9	+7	+11	+14	+10	+5	+2	0	−2	−5	−5	−6	−4	−4	−6	−5
December	−6	−5	−6	−6	−6	−2	−1	+2	+5	+2	+4	+13	+10	+7	+5	+3	+5	0	0	−4	−7	−1	−10	−3	−4
Means	−6	−5	−5	−4	−4	−3	−2	0	+1	+2	+4	+6	+9	+10	+8	+4	+1	−2	−2	−4	−4	−4	−4	−3	−3
Summer.																									
April	−4	−5	−3	−4	−3	−2	−4	−4	−7	−7	−1	+9	+13	+15	+12	+10	+3	0	−2	−2	−2	−1	+1	+2	+2
May	−6	−7	−7	−6	−6	−6	−6	−8	−7	−4	+4	+18	+19	+18	+14	+6	0	−3	−3	−4	−4	−2	−3	−3	0
June	0	−3	0	0	−1	0	+2	−1	−5	−7	−2	+5	+7	+12	+11	+8	−1	−4	−5	−8	−5	+2	−3	−1	0
July	−1	−3	−2	−2	−4	−2	0	−2	−3	−8	−1	+4	+10	+12	+12	+8	+2	−2	−4	−4	−3	−1	−2	0	+3
August	−3	0	0	−1	0	+1	+2	0	−8	−11	−14	−14	−3	+7	+11	+8	+5	0	+2	+3	+3	+4	+1	+1	+10
September	+5	+5	+1	0	+2	+2	0	−7	−16	−19	−16	−12	0	+5	+8	+11	+9	+8	+4	+3	0	+2	+3	+3	+7
Means	−1	−2	−2	−2	−2	−1	−1	−3	−7	−8	−5	+2	+8	+12	+12	+9	+3	0	−1	−2	−2	+1	0	+1	+4

Hourly Means of the Declination as determined at Dehra Dūn from the selected quiet days in 1910.

E.2°+

Winter.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	33·5	33·4	33·4	33·3	33·3	33·1	33·0	33·1	33·3	34·3	34·7	31·5	33·5	33·2	33·2	33·1	33·1	33·5	33·4	33·4	33·3	33·3	33·3	33·3	33·2	33·4
February .	33·6	33·6	33·7	33·6	33·5	33·3	33·2	33·1	33·6	34·0	33·6	33·1	32·8	32·7	33·2	33·6	33·7	33·7	33·2	33·3	33·4	33·5	33·5	33·5	33·6	33·4
March .	33·3	33·2	33·1	33·1	32·9	32·8	33·2	34·3	35·5	35·8	35·2	33·4	31·9	31·4	31·8	32·5	33·2	33·4	33·1	33·0	33·1	33·2	33·1	33·2	33·2	33·3
October .	31·7	31·9	32·1	31·6	31·4	31·8	31·7	32·5	33·1	32·7	31·5	30·7	29·4	28·9	29·3	30·6	31·4	31·5	31·1	31·2	31·4	31·4	31·4	31·5	31·7	31·3
November .	31·3	31·1	30·6	30·6	30·3	30·4	30·3	30·4	31·0	31·4	31·3	31·2	30·6	30·5	30·7	31·0	31·0	30·9	31·0	31·0	31·0	31·1	31·2	31·4	31·4	30·9
December .	30·6	30·5	30·4	30·2	30·2	29·9	29·8	29·7	30·2	31·0	30·9	30·5	30·3	30·0	30·1	30·5	30·6	30·8	30·7	30·6	30·7	30·5	30·9	30·8	30·5	30·4
Means .	32·3	32·3	32·2	32·1	31·9	31·9	31·9	32·2	32·8	33·2	32·9	32·2	31·4	31·1	31·4	31·9	32·2	32·3	32·1	32·1	32·2	32·2	32·2	32·3	32·3	32·1

Summer.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
April .	32·5	32·7	32·7	32·7	32·6	32·5	33·0	33·8	34·9	34·9	33·7	31·6	30·2	29·4	29·8	30·7	31·7	32·0	32·2	32·0	31·9	32·0	32·2	32·4	32·6	32·2
May . .	33·5	32·8	32·7	32·8	32·8	32·8	33·6	34·6	35·1	34·2	32·2	30·4	29·3	29·3	30·1	31·1	31·8	32·2	32·1	31·9	31·8	31·8	32·1	32·4	32·6	32·2
June . .	32·1	32·3	32·2	32·3	33·4	32·4	33·7	35·1	35·1	34·1	32·3	30·8	29·2	28·2	28·2	29·2	30·6	31·8	33·0	31·8	31·5	31·5	31·8	31·7	31·9	31·8
July . .	31·6	31·7	31·9	31·9	32·0	32·2	33·3	33·9	33·6	33·1	32·1	30·5	29·5	29·0	29·3	29·9	30·3	30·7	30·9	30·7	30·7	30·8	31·0	31·1	31·4	31·3
August .	31·6	31·7	31·7	31·8	32·0	32·2	33·3	34·3	34·4	33·8	32·2	30·6	29·2	28·3	28·5	29·4	30·3	30·9	31·3	31·2	31·3	31·3	31·6	31·7	31·6	31·4
September .	31·4	31·4	31·6	31·6	31·6	31·8	32·3	33·5	33·9	32·9	31·2	29·5	28·6	28·4	29·1	30·1	31·0	31·2	31·1	31·0	30·9	31·0	31·3	31·3	31·4	31·1
Means	32·0	32·1	32·1	32·2	32·2	32·3	33·2	34·2	34·5	33·8	32·3	30·6	29·3	28·8	29·2	30·1	31·0	31·5	31·6	31·4	31·4	31·4	31·7	31·8	31·9	31·7

Diurnal Inequality of the Declination at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	+0·1	0·0	0·0	−0·1	−0·1	−0·3	−0·4	−0·3	−0·1	+0·9	+1·3	+1·1	+0·1	−0·2	−0·2	−0·3	−0·3	+0·1	0·0	0·0	−0·1	−0·1	−0·1	−0·1	−0·2
February . .	+0·2	+0·2	+0·3	+0·2	+0·1	−0·1	−0·2	−0·3	+0·2	+0·6	+0·2	−0·3	−0·6	−0·7	−0·2	+0·2	+0·3	+0·3	−0·2	−0·1	0·0	+0·1	+0·1	+0·1	+0·2
March . .	0	−0·1	−0·2	−0·2	−0·4	−0·5	−0·1	+1·0	+2·2	+2·5	+1·9	+0·1	−1·4	−1·9	−1·5	−0·8	−0·1	+0·1	−0·2	−0·3	−0·2	−0·1	−0·2	−0·1	−0·1
October . .	+0·4	+0·6	+0·8	+0·3	+0·1	+0·5	+0·4	+1·2	+1·8	+1·4	+0·2	−0·6	−1·9	−2·4	−2·0	−0·7	+0·1	+0·2	−0·2	−0·1	+0·1	+0·1	+0·1	+0·2	+0·4
November . .	+0·4	+0·2	−0·3	−0·3	−0·6	−0·5	−0·6	−0·5	+0·1	+0·5	+0·4	+0·3	−0·3	−0·4	−0·2	+0·1	+0·1	0	+0·1	+0·1	+0·1	+0·2	+0·3	+0·5	+0·5
December . .	+0·2	+0·1	0·0	−0·2	−0·2	−0·5	−0·6	−0·7	−0·2	+0·6	+0·5	+0·1	−0·1	−0·4	−0·3	+0·1	+0·2	+0·4	+0·3	+0·2	+0·3	+0·1	+0·5	+0·4	+0·1
Means . .	+0·2	+0·2	+0·1	0·0	−0·2	−0·2	−0·2	+0·1	+0·7	+1·1	+0·8	−0·1	−0·7	−1·0	−0·7	−0·2	+0·1	+0·2	0·0	0·0	+0·1	+0·1	+0·1	+0·2	+0·2
Summer.																									
April . . .	+0·3	+0·5	+0·5	+0·5	+0·4	+0·3	+0·8	+1·6	+2·7	+2·7	+1·5	−0·6	−2·0	−2·8	−2·4	−1·5	−0·5	−0·2	0·0	−0·2	−0·3	−0·2	0·0	+0·2	+0·4
May . . .	+0·3	+0·6	+0·5	+0·6	+0·6	+0·6	+1·4	+2·4	+2·9	+2·0	0	−1·8	−2·9	−2·9	−2·1	−1·1	−0·4	0·0	−0·1	−0·3	−0·4	−0·4	−0·1	+0·2	+0·4
June . . .	+0·3	+0·5	+0·4	+0·5	+0·6	+0·6	+1·9	+3·3	+3·3	+2·3	+0·5	−1·0	−2·6	−3·6	−3·6	−2·6	−1·2	0·0	+0·2	0·0	−0·3	−0·3	9·0	−0·1	+0·1
July . . .	+0·3	+0·4	+0·6	+0·6	+0·7	+0·9	+2·0	+2·6	+2·3	+1·8	+0·8	−0·8	−1·8	−2·3	−2·0	−1·4	−1·0	−0·6	−0·4	−0·6	−0·6	−0·5	−0·3	−0·2	+0·1
August . .	+0·2	+0·3	+0·3	+0·4	+0·6	+0·8	+1·9	+2·9	+3·0	+2·4	+0·8	−0·8	−2·2	−3·1	−2·9	−2·0	−1·1	−0·5	−0·1	−0·2	−0·1	−0·1	+0·2	+0·3	−0·2
September . .	+0·3	+0·3	+0·5	+0·5	+0·5	+0·7	+1·2	+2·4	+2·8	+1·8	+0·1	−1·6	−2·5	−2·7	−2·0	−1·0	−0·1	+0·1	0·0	−0·1	−0·2	−0·1	+0·2	+0·2	+0·3
Means . .	+0·3	+0·4	+0·4	+0·5	+0·5	+0·6	+1·5	+2·5	+2·8	+2·1	+0·6	−1·1	−2·4	−2·9	−2·5	−1·6	−0·7	−0·2	−0·1	−0·3	−0·3	−0·3	0·0	+0·1	+0·2

NOTE.—When the sign is + the magnet points to the East and when − to the West of the mean position.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Dehra Dūn from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
	·31900 +																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	073	073	073	072	072	072	073	074	077	**078**	074	066	**063**	066	065	068	072	074	074	074	074	075	075	075	075	672
February	77	77	76	**77**	77	76	77	76	77	76	71	**65**	66	70	72	73	74	74	75	75	76	76	77	77	76	74
March	84	84	84	84	84	84	84	87	87	82	75	**67**	69	73	80	84	86	84	84	85	87	87	88	**88**	88	82
October	159	158	158	159	159	158	158	160	157	153	151	144	**144**	148	152	157	160	159	157	157	159	159	**160**	160	160	156
November	166	166	167	166	166	166	167	167	168	168	165	165	**163**	163	164	167	168	169	169	169	170	**171**	170	170	171	167
December	172	172	171	171	171	171	171	171	173	172	169	167	165	**165**	169	172	172	172	173	172	172	**174**	172	174	174	171
Means	122	122	122	122	122	121	122	123	123	122	118	112	**112**	114	117	120	122	122	122	123	123	124	124	**124**	124	120
													Summer.													
April	089	088	088	088	088	087	090	**092**	091	084	076	071	**070**	073	080	085	088	090	089	089	089	090	091	091	091	086
May	108	107	107	106	107	103	**110**	109	106	097	**092**	094	099	103	108	110	109	108	107	107	107	109	109	110	110	106
June	119	119	120	119	119	122	**126**	124	120	111	109	100	**099**	100	104	110	115	121	119	117	119	120	119	118	119	115
July	133	132	132	132	132	134	**137**	134	132	129	124	**118**	118	121	125	128	130	131	131	130	133	134	134	134	135	130
August	125	126	126	126	127	129	130	130	126	120	**115**	117	116	119	123	130	133	137	140	141	142	144	144	144	**145**	129
September	140	139	139	139	140	139	141	142	140	136	131	**129**	132	134	138	140	141	140	139	140	140	142	142	142	**143**	139
Means	119	119	119	118	119	120	122	122	119	113	108	**105**	106	108	113	117	119	121	121	121	122	123	123	123	**124**	118

Diurnal Inequality of the Vertical Force at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+1	+1	+1	0	0	0	+1	+2	+5	+6	+2	−6	−9	−6	−7	−4	0	+2	+2	+2	+2	+3	+3	+3	+3
February	+3	+3	+2	+3	+3	+2	+3	+2	+3	+2	−3	−9	−8	−4	−2	−1	0	0	+1	+1	+2	+2	+3	+3	+2
March	+2	+2	+2	+2	+2	+2	+2	+5	+5	0	−7	−15	−13	−9	−2	+2	+4	+2	+2	+3	+5	+5	+6	+6	+6
October	+3	+2	+2	+3	+3	+2	+2	+4	+1	−3	−5	−12	−12	−8	−4	+1	+4	+3	+1	+1	+3	+3	+4	+4	+4
November	−1	−1	0	−1	−1	−1	0	0	+1	+1	−2	−2	−4	−4	−3	0	+1	+2	+2	+2	+3	+4	+3	+3	+4
December	+1	+1	0	0	0	0	0	0	+2	+1	−2	−4	−6	−6	−2	+1	+1	+1	+2	+1	+1	+3	+1	+3	+3
Means	+2	+2	+2	+2	+2	+1	+2	+3	+3	+2	−2	−8	−8	−6	−3	0	+2	+2	+2	+2	+3	+4	+4	+4	+4
Summer.																									
April	+3	+2	+2	+2	+2	+1	+4	+6	+5	−2	−10	−15	−16	−13	−6	−1	+2	+4	+3	+3	+3	+4	+5	+5	+5
May	+2	+1	+1	0	+1	+2	+4	+3	0	−9	−14	−12	−7	−3	+2	+4	+3	+2	+1	+1	+1	+3	+3	+4	+4
June	+4	+4	+5	+4	+4	+7	+11	+9	+5	−4	−6	−15	−16	−15	−11	−5	0	+6	+4	+2	+4	+5	+4	+3	+4
July	+3	+2	+2	+2	+2	+4	+7	+4	+2	−1	−6	−12	−12	−9	−5	−2	0	+1	+1	0	+3	+4	+4	+4	+5
August	−4	−3	−3	+3	−2	0	+1	+1	−3	−9	−14	−12	−13	−10	−6	+1	+4	+8	+11	+12	+13	+15	+15	+15	+16
September	+1	0	0	0	+1	0	+2	+3	+1	−3	−8	−10	−7	−5	−1	+1	+2	+1	0	+1	+1	+3	+3	+3	+4
Means	+1	+1	+1	0	+1	+2	+4	+4	+1	−5	−10	−13	−12	−10	−5	−1	+1	+3	+3	+3	+4	+5	+5	+5	+6

NOTE.—When the sign is + the V. F. is more and when − it is less than the mean.

Hourly Means of the Dip as determined at Dehra Dūn from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
N. 43°+												Winter.														
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	52·1	52·2	52·1	52·1	52·1	52·0	52·0	51·8	51·8	51·9	51·9	51·7	51·6	51·7	51·7	51·9	52·0	52·3	52·1	52·1	52·1	52·2	52·2	52·2	52·2	52·0
February	52·7	52·6	52·7	52·5	52·5	52·4	52·4	52·2	52·3	52·0	51·8	51·4	51·2	51·3	51·6	51·9	52·3	52·6	52·5	52·5	52·5	52·5	52·5	52·5	52·4	52·2
March	52·8	52·6	52·6	52·7	52·7	52·5	52·6	52·8	52·8	52·4	51·8	51·3	51·1	51·1	51·4	52·0	52·4	52·5	52·6	52·8	52·9	53·0	52·9	52·9	52·7	52·4
October	58·1	58·0	58·1	58·1	58·0	58·0	58·0	58·2	58·1	57·9	57·3	56·7	56·4	56·4	56·8	57·3	57·6	57·7	57·6	57·8	57·9	57·9	57·8	57·9	57·9	57·7
November	58·4	58·4	58·2	58·2	58·2	58·2	58·2	58·0	57·8	57·7	57·6	57·4	57·2	57·4	57·7	58·0	58·2	58·4	58·5	58·5	58·6	58·5	58·5	58·6	58·6	58·1
December	58·4	58·4	58·4	58·4	58·4	58·2	58·1	58·0	57·9	58·0	57·3	57·2	57·2	57·4	57·7	58·0	57·9	58·1	58·2	58·4	58·5	58·3	58·7	58·4	58·4	58·1
Means	55·4	55·4	55·4	55·3	55·3	55·2	55·2	55·2	55·1	55·0	54·7	54·3	54·1	54·2	54·5	54·9	55·1	55·3	55·3	55·4	55·4	55·4	55·4	55·4	55·4	55·1
													Summer.													
April	53·5	53·5	53·4	53·4	53·4	53·3	53·5	53·6	53·7	53·3	52·6	51·8	51·6	51·6	52·1	52·5	53·1	53·3	53·4	53·4	53·4	53·3	53·3	53·3	53·3	53·1
May	53·9	53·9	53·9	53·8	53·8	53·9	54·0	54·0	53·8	53·2	52·5	51·9	52·1	52·3	52·8	53·4	53·6	53·7	53·7	53·7	53·7	53·7	53·8	53·8	53·7	53·5
June	54·5	54·6	54·5	54·5	54·5	54·6	54·7	54·8	54·8	54·4	54·0	53·2	53·0	52·8	53·1	53·6	54·3	54·8	54·7	54·8	54·7	54·4	54·6	54·4	54·5	54·3
July	55·0	55 0	55·0	55·0	55·1	55·1	55·2	55·1	55·0	54·9	54·5	53·9	53·6	53·7	53·9	54·3	54 7	55·0	55·0	55·0	55·1	55·0	55·1	55·0	54·9	54 8
August	55·5	55·4	55·4	55·4	55·5	55·5	55·5	55·6	35·8	55·6	55·5	55 6	55·0	54·7	54·7	55·2	55·5	56·0	56·0	56·1	56·1	56·2	56·3	56·3	55·9	55·6
September	55·8	55·7	55·9	56·0	55·9	55·9	56·1	56·5	56·9	56·8	56·4	56·1	55·6	55·5	55·6	55·5	55·7	55·6	55·8	55·9	56·0	56·1	56·0	56·0	55·8	56·0
Means	54·7	54·7	54·7	54·7	54·7	54·7	54·8	54·9	55·0	54·7	54·3	53·8	53·5	53·4	53·7	54·1	54·5	54·7	54·8	54·8	54·8	54·8	54·9	54·8	54·7	54·6

Diurnal Inequality of the Dip at Dehra Dūn as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·1	+0·2	+0·1	+0·1	+0·1	0·0	0·0	−0·2	−0·2	−0·1	−0·1	−0·3	−0·4	−0·3	−0·3	−0·1	0·0	+0·3	+0·1	+0·1	+0·1	+0·2	+0·2	+0·2	+0·2
February	+0·5	+0·4	+0·5	+0·3	+0·3	+0·2	+0·2	0·0	+0·1	−0·2	−0·4	−0·8	−1·0	−0·9	−0·6	−0·3	+0·1	+0·4	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3	+0·2
March	+0·4	+0·2	+0·2	+0·3	+0·3	+0·1	+0·2	+0·4	+0·4	0·0	−0·6	−1·1	−1·3	−1·3	−1·0	−0·4	0·0	+0·1	+0·2	+0·4	+0·5	+0·6	+0·5	+0·5	+0·3
October	+0·4	+0·3	+0·4	+0·4	+0·3	+0·3	+0·3	+0·5	+0·4	+0·2	−0·4	−1·0	−1·3	−1·3	−0·9	−0·4	−0·1	0·0	−0·1	+0·1	+0·2	+0·2	+0·1	+0·2	+0·2
November	+0·3	+0·3	+0·1	+0·1	+0·1	+0·1	+0·1	−0·1	−0·3	−0·4	−0·5	−0·7	−0·9	−0·7	−0·4	−0·1	+0·1	+0·3	+0·4	+0·4	+0·5	+0·4	+0·4	+0·5	+0·5
December	+0·3	+0·3	+0·3	+0·3	+0·3	−0·1	0·0	−0·1	−0·2	−0·1	−0·3	−0·9	−0·9	−0·7	−0·4	−0·1	−0·2	0·0	+0·1	+0·3	+0·4	+0·2	+0·6	+0·3	+0·3
Means	+0·3	+0·3	+0·3	+0·2	+0·2	+0·1	+0·1	+0·1	0·0	−0·1	−0·4	−0·8	−1·0	−0·9	−0·6	−0·2	0·0	+0·2	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	+0·3
Summer.																									
April	+0·4	+0·4	+0·3	+0·3	+0·3	+0·2	+0·4	+0·5	+0·6	+0·2	−0·5	−1·3	−1·5	−1·5	−1·0	−0·6	0·0	+0·2	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·2
May	+0·4	+0·4	+0·4	+0·3	+0·3	+0·4	+0·5	+0·5	+0·3	−0·3	−1·0	−1·6	−1·4	−1·2	−0·7	−0·1	+0·1	+0·2	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	+0·2
June	+0·2	+0·3	+0·2	+0·2	+0·2	+0·3	+0·4	+0·5	+0·5	+0·1	−0·3	−1·1	−1·3	−1·5	−1·2	−0·7	0·0	+0·5	+0·4	+0·5	+0·4	+0·1	+0·3	+0·1	+0·2
July	+0·2	+0·2	+0·2	+0·2	+0·3	+0·3	+0·4	+0·3	+0·2	+0·1	−0·3	−0·9	−1·2	−1·1	−0·9	−0·5	−0·1	+0·2	+0·2	+0·2	+0·3	+0·2	+0·3	+0·2	+0·1
August	−0·1	−0·2	−0·2	−0·2	−0·1	−0·1	−0·1	0·0	+0·2	0·0	−0·1	0·0	−0·6	−0·9	−0·9	−0·4	−0·1	+0·4	+0·4	+0·5	+0·5	+0·6	+0·7	+0·7	+0·3
September	−0·2	−0·3	−0·1	0·0	−0·1	−0·1	+0·1	+0·5	+0·9	+0·8	+0·4	−0·1	−0·4	−0·5	−0·4	−0·5	−0·3	−0·4	−0·2	−0·1	0·0	+0·1	0·0	0·0	−0·2
Means	+0·1	+0·1	+0·1	+0·1	+0·1	+0·1	+0·2	+0·3	+0·4	+0·1	−0·3	−0·8	−1·1	−1·2	−0·9	−0·5	−0·1	+0·1	+0·2	+0·2	+0·2	+0·2	+0·3	+0·2	+0·1

NOTE.—When the sign is + the Dip is more and when − it is less than the mean.

E.—Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Barrackpore from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
		·37000											Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	313	314	314	313	314	315	317	321	327	**329**	328	328	325	324	322	319	317	315	312	313	313	312	**312**	313	313	318
February .	**308**	309	310	309	312	314	314	320	324	326	332	334	**336**	333	329	323	316	308	309	310	309	309	308	311	311	317
March .	315	314	318	318	318	319	320	321	324	332	342	**348**	346	342	338	332	323	321	317	315	311	311	311	311	314	323
October .	**315**	320	318	318	317	320	321	319	321	327	337	346	349	**351**	343	334	328	327	327	325	323	324	324	324	325	327
November .	**319**	322	320	324	325	326	326	332	337	342	348	351	**353**	347	338	333	331	329	326	322	322	320	323	323	323	331
December .	331	333	333	334	334	335	338	342	346	348	349	358	**358**	355	353	347	345	342	338	336	332	331	335	**330**	336	341
Means .	**317**	319	319	319	320	322	323	326	330	334	339	344	**345**	342	337	331	327	324	322	320	318	318	319	319	320	326
													Summer.													
April .	310	312	313	313	313	314	315	**309**	313	322	334	341	**347**	346	336	327	323	317	315	313	312	312	314	315	316	320
May .	**320**	323	322	324	321	324	326	327	333	342	349	**353**	352	349	342	335	328	323	325	324	323	323	325	325	326	331
June .	325	327	324	328	329	330	328	331	330	338	345	347	349	**349**	345	338	330	317	**315**	316	317	318	322	321	323	330
July .	**328**	331	329	330	330	331	333	338	339	344	349	353	**357**	356	350	342	336	330	328	329	328	328	331	331	332	337
August .	326	**323**	327	328	328	328	333	334	336	339	342	346	356	**359**	355	349	343	334	330	331	332	331	331	328	328	336
September .	339	341	340	339	339	341	341	337	**331**	331	336	341	342	350	**351**	350	348	345	343	339	338	339	339	340	340	341
Means .	**325**	326	326	327	327	328	329	329	330	336	343	347	351	**352**	347	340	335	328	326	325	325	325	327	327	328	333

Diurnal Inequality of the Horizontal Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon	13	14	15	16	17	18	19	20	21	22	23	Mid.
1910													Winter.												
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	−5	−4	−4	−5	−4	−3	−1	+3	+9	+11	+10	+10	+7	+6	+4	+1	−1	−3	−6	−5	−5	−6	−6	−5	−5
February	−9	−8	−7	−8	−5	−3	−3	+3	+7	+9	+15	+17	+19	+16	+12	+6	−1	−9	−8	−7	−8	−8	−9	−6	−6
March	−8	−9	−5	−5	−5	−4	−3	−2	+1	+9	+19	+25	+23	+19	+15	+9	0	−2	−6	−8	−12	−12	−12	−12	−9
October	−12	−7	−9	−9	−10	−7	−6	−8	−6	0	+10	+19	+22	+24	+16	+7	+1	0	0	−2	−4	−3	−3	−3	−2
November	−12	−9	−11	−7	−6	−5	−5	+1	+6	+11	+17	+20	+22	+16	+7	+2	0	−2	−5	−9	−9	−11	−8	−8	−8
December	−10	−8	−8	−7	−7	−6	−3	+1	+5	+7	+8	+17	+17	+14	+12	+6	+4	+1	−3	−5	−9	−10	−6	−11	−5
Means	−9	−7	−7	−7	−6	−4	−3	0	+4	+8	+13	+18	+19	+16	+11	+5	+1	−2	−4	−6	−8	−8	−7	−7	−6
													Summer.												
April	−10	−8	−7	−7	−7	−6	−5	−11	−7	+2	+14	+21	+27	+26	+16	+7	+3	−3	−5	−7	−8	−8	−6	−5	−4
May	−11	−8	−9	−7	−7	−7	−5	−4	+2	+11	+18	+22	+21	+18	+11	+4	−3	−8	−6	−7	−8	−8	−6	−6	−5
June	−5	−3	−6	−2	−1	0	−2	+1	0	+8	+15	+17	+19	+19	+15	+8	0	−13	−15	−14	−13	−12	−8	−9	−7
July	−9	−6	−8	−7	−7	−6	−4	+1	+2	+7	+12	+16	+20	+19	+13	+5	−1	−7	−9	−8	−9	−9	−6	−6	−5
August	−10	−13	−9	−8	−8	−8	−3	−2	0	+3	+6	+10	+20	+23	+19	+13	+7	−2	−6	−5	−4	−5	−5	−8	−8
September	−2	0	−1	−2	−2	0	0	−4	−10	−10	−5	0	+1	+9	+10	+9	+7	+4	+3	−2	−3	−2	−2	−1	−1
Means	−8	−7	−7	−6	−6	−5	−4	−4	−3	+3	+10	+14	+18	+19	+14	+7	+2	−5	−7	−8	−8	−8	−6	−6	−5

Hourly Means of the Declination as determined at Barrackpore from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
0° E. +													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	58·0	57·8	57·8	57·7	57·8	57·5	56·3	57·2	58·1	59·6	60·4	59·9	58·4	57·9	57·5	57·4	57·7	58·0	58·1	58·1	58·1	58·0	58·0	58·0	53·1	58·1
February .	57·7	57·7	57·8	57·7	57·7	57·5	57·2	57·3	57·8	58·3	57·9	57·4	57·1	57·6	57·7	58·0	58·2	57·8	57·3	57·5	57·6	57·5	57·6	57·6	57·7	57·6
March .	57·2	57·3	57·1	57·1	57·0	56·9	57·0	58·1	59·3	59·6	58·9	57·4	56·5	56·1	56·7	57·4	57·8	57·6	57·0	57·0	57·0	57·1	57·2	57·2	57·2	57·4
October .	54·0	54·0	54·0	54·2	54·0	53·7	54·0	55·1	55·7	55·3	54·4	53·3	52·3	52·0	52·7	53·8	54·7	54·6	53·9	53·8	53·9	54·0	54·0	53·9	54·0	54·0
November .	53·7	53·7	53·5	53·3	53·2	53·0	53·1	53·0	53·5	54·2	54·2	53·6	53·2	53·3	53·4	53·6	53·7	53·7	53·5	53·5	53·4	53·4	53·5	53·5	53·5	53·5
December .	52·9	52·9	52·8	52·5	52·5	52·3	52·2	51·9	52·6	53·5	53·5	53·1	53·0	52·6	52·4	52·7	53·2	53·2	53·3	53·2	53·0	52·9	52·8	52·9	52·9	52·8
Means .	55·6	55·6	55·5	55·4	55·4	55·2	55·1	55·4	56·2	56·8	56·6	55·8	55·1	54·9	55·1	55·5	55·9	55·8	55·5	55·5	55·5	55·5	55·5	55·5	55·6	55·6
													Summer.													
April .	56·8	57·0	57·0	57·0	56·9	56·7	57·3	58·3	58·8	58·5	57·4	55·7	54·5	54·2	54·7	55·8	56·4	56·9	56·7	56·3	56·3	56·3	56·5	56·7	56·8	56·6
May .	56·3	56·4	56·6	56·5	56·5	56·6	57·5	58·0	58·5	57·4	55·9	54·3	53·6	54·0	54·9	55·5	56·1	56·5	56·0	55·7	55·7	55·8	55·9	56·1	56·4	56·1
June .	55·8	56·1	56·1	56·1	56·1	56·4	57·7	59·1	59·3	57·9	56·5	54·3	52·9	52·7	53·1	54·0	55·2	56·2	56·2	55·9	55·3	55·5	55·5	55·6	55·7	55·8
July .	55·2	55·3	55·5	55·7	55·5	55·8	57·0	57·8	57·8	56·8	55·6	54·1	53·5	53·3	53·8	54·3	54·6	55·0	54·9	54·5	54·6	54·6	54·7	54·9	55·1	55·2
August .	54·7	54·9	55·0	55·1	55·4	55·6	56·7	57·7	57·7	56·7	54·8	52·8	51·9	51·8	91·8	52·4	53·5	54·3	54·4	54·1	54·1	54·1	54·3	54·3	54·7	54·5
September .	54·3	54·3	54·5	54·7	54·7	54·9	55·8	57·2	57·1	55·9	53·9	52·2	51·3	51·4	52·2	53·7	54·6	54·8	54·3	54·0	54·0	54·0	54·1	54·2	54·3	54·2
Means .	55·5	55·7	55·8	55·8	55·9	56·0	57·0	58·1	58·2	57·2	55·7	53·9	53·0	52·9	53·4	54·3	55·1	55·6	55·4	55·1	55·0	55·1	55·2	55·3	55·5	55·4

Diurnal Inequality of the Declination at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1910. Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January . .	−0·1	−0·3	−0·3	−0·4	−0·3	−0·6	−0·8	−0·9	0·0	+1·5	+2·3	+1·8	+0·3	−0·2	−0·6	−0·7	−0·4	−0·1	0·0	0·0	0·0	−0·1	−0·1	−0·1	0·0
February . .	+0·1	+0·1	+0·2	+0·1	+0·1	−0·1	−0·4	−0·3	+0·2	+0·7	+0·3	−0·2	−0·5	0·0	+0·1	+0·4	+0·6	+0·2	−0·3	−0·1	0·0	−0·1	0·0	0·0	+0·1
March . .	−0·2	−0·1	−0·3	−0·3	−0·4	−0·5	−0·4	+0·7	+1·9	+2·2	+1·5	0·0	−0·9	−1·3	−0·7	0·0	+0·4	+0·2	−0·4	−0·4	−0·4	−0·3	−0·2	−0·2	−0·2
October . .	0·0	0·0	0·0	+0·2	0·0	−0·3	0·0	+1·1	+1·7	+1·3	+0·4	−0·7	−1·7	−2·0	−1·3	−0·2	+0·7	+0·6	−0·1	−0·2	−0·1	0·0	0·0	−0·1	0·0
November . .	+0·2	+0·2	0·0	−0·2	−0·3	−0·5	−0·4	−0·5	0·0	+0·7	+0·7	+0·1	−0·3	−0·2	−0·1	+0·1	+0·2	+0·2	0·0	0·0	−0·1	−0·1	0·0	0·0	0·0
December . .	+0·1	+0·1	0·0	−0·3	−0·3	−0·5	−0·6	−0·9	−0·2	+0·7	+0·7	+0·3	+0·2	−0·2	−0·4	−0·1	+0·4	+0·4	+0·5	+0·4	+0·2	+0·1	0·0	+0·1	+0·1
Means . .	0·0	0·0	−0·1	−0·2	−0·2	−0·4	−0·5	−0·2	+0·6	+1·2	+1·0	+0·2	−0·5	−0·7	−0·5	−0·1	+0·3	+0·2	−0·1	−0·1	−0·1	−0·1	−0·1	−0·1	0·0
Summer.																									
April . . .	+0·2	+0·4	+0·4	+0·4	+0·3	+0·1	+0·7	+1·7	+2·2	+1·9	+0·8	−0·9	−2·1	−2·4	−1·9	−0·8	−0·2	+0·3	+0·1	−0·3	−0·3	−0·3	−0·1	+0·1	+0·2
May . . .	+0·2	+0·3	+0·5	+0·4	+0·4	+0·5	+1·4	+2·5	+2·4	+1·3	−0·2	−1·8	−2·5	−2·1	−1·2	−0·6	0·0	+0·4	−0·1	−0·4	−0·4	−0·3	−0·2	0·0	+0·3
June . . .	0·0	+0·3	+0·3	+0·3	+0·3	+0·6	+1·9	+3·3	+3·5	+2·1	+0·7	−1·5	−2·9	−3·1	−2·7	−1·8	−0·6	+0·4	+0·4	+0·1	−0·5	−0·3	−0·3	−0·2	−0·1
July . . .	0·0	+0·1	+0·3	+0·3	+0·3	+0·6	+1·8	+2·6	+2·6	+1·6	+0·4	−1·1	−1·7	−1·9	−1·4	−0·9	−0·6	−0·2	−0·3	−0·7	−0·6	−0·6	−0·5	−0·3	−0·1
August . .	+0·2	+0·4	+0·5	+0·6	+0·9	+1·1	+2·2	+3·2	+3·2	+2·2	+0·3	−1·7	−2·6	−2·7	−2·7	−2·1	−1·0	−0·2	−0·1	−0·4	−0·4	−0·4	−0·3	−0·2	+0·2
September . .	+0·1	+0·1	+0·3	+0·5	+0·5	+0·7	+1·6	+3·0	+2·9	+1·7	−0·3	−2·0	+2·9	−2·8	−2·0	−0·5	+0·4	+0·6	+0·1	−0·2	−0·2	−0·2	−0·1	0·0	+0·1
Means . .	+0·1	+0·3	+0·4	+0·4	+0·5	+0·6	+1·6	+2·7	+2·8	+1·8	+0·3	−1·5	−2·4	−2·5	−2·0	−1·1	−0·3	+0·2	0	−0·3	−0·4	−0·3	−0·2	−0·1	+0·1

NOTE.—When the sign is + the magnet points to the East and when − to the West of the mean position.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Barrackpore from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
		·22000+											Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	137	138	138	138	138	138	138	139	141	138	133	125	123	121	119	124	128	132	134	134	135	135	136	136	136	138
February .	143	143	143	144	143	144	144	146	146	140	137	135	135	134	136	138	138	139	141	142	142	142	143	142	142	141
March .	147	147	149	149	149	149	149	150	146	140	134	130	131	132	136	140	142	143	144	145	146	147	148	148	148	143
October .	190	191	190	190	189	190	191	191	189	185	183	180	179	182	185	187	188	187	188	188	188	187	187	188	187	187
November .	199	199	198	199	199	200	199	200	198	195	192	189	191	192	192	193	194	195	197	198	197	197	197	197	197	196
December .	196	196	196	197	196	197	197	198	200	197	193	191	187	184	185	187	190	192	193	193	194	194	195	194	195	193
Means .	169	169	169	170	169	170	170	171	170	166	162	158	158	158	159	162	163	165	166	167	167	167	168	168	168	166
													Summer.													
April .	155	155	156	156	156	157	158	158	156	148	143	140	142	147	151	154	156	156	156	157	156	157	158	158	158	153
May . .	166	166	166	166	166	166	168	164	159	156	157	158	161	162	164	164	165	165	165	165	166	165	166	166	166	164
June .	169	169	169	169	170	171	173	171	167	165	161	155	158	161	164	165	166	166	166	168	170	170	171	170	171	167
July . .	171	171	171	171	170	171	172	170	167	165	161	160	160	162	164	165	167	168	170	170	172	171	172	172	172	168
August .	185	185	184	184	184	186	187	184	180	173	171	170	169	174	177	180	182	183	183	184	185	186	187	187	186	181
September .	190	190	189	189	189	189	191	188	183	181	177	176	179	182	184	185	186	186	186	188	189	190	190	190	189	186
Means .	173	173	173	173	173	173	175	173	169	165	162	160	162	165	167	169	170	171	171	172	173	173	174	174	174	170

Diurnal Inequality of the Vertical Force at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+4	+5	+5	+5	+5	+5	+5	+6	+8	+5	0	−8	−10	−12	−14	−9	−5	−1	+1	+1	+2	+2	+3	+3	+3
February	+2	+2	+2	+3	+2	+3	+3	+5	+5	−1	−4	−6	−6	−7	−5	−3	−3	−2	0	+1	+1	+1	+2	+1	+1
March	+4	+4	+6	+6	+6	+6	+6	+7	+3	−3	−9	−13	−12	−11	−7	−3	−1	0	+1	+2	+3	+4	+5	+5	+5
October	+3	+4	+3	+3	+2	+3	+4	+4	+2	−2	−4	−7	−8	−5	−2	0	+1	0	+1	+1	+1	0	0	+1	0
November	+3	+3	+2	+3	+3	+4	+3	+4	+2	−1	−4	−7	−5	−4	−4	−3	−2	−1	+1	+2	+1	+1	+1	+1	+1
December	+3	+3	+3	+4	+3	+4	+4	+5	+7	+4	0	−2	−6	−9	−8	−6	−3	−1	0	0	+1	+1	+2	+1	+2
Means	+3	+3	+3	+4	+3	+4	+4	+5	+4	0	−4	−8	−8	−8	−7	−4	−3	−1	0	+1	+1	+1	+2	+2	+2
Summer.																									
April	+2	+2	+3	+3	+3	+4	+5	+5	+3	−5	−10	−13	−11	−6	−2	+1	+3	+3	+3	+4	+3	+4	+5	+5	+5
May	+2	+2	+2	+2	+2	+2	+4	0	−5	−8	−7	−6	−3	−2	0	0	+1	+1	+1	+1	+2	+1	+2	+2	+2
June	+2	+2	+2	+2	+3	+4	+6	+4	0	−2	−6	−12	−9	−6	−3	−2	−1	−1	−1	+1	+3	+3	+4	+3	+4
July	+3	+3	+3	+3	+2	+3	+4	+2	−1	−3	−7	−8	−8	−6	−4	−3	−1	0	+2	+2	+4	+3	+4	+4	+4
August	+4	+4	+3	+3	+3	+5	+6	+3	−1	−8	−10	−11	−12	−7	−4	−1	+1	+2	+2	+3	+4	+5	+6	+6	+5
September	+4	+4	+3	+3	+3	+3	+5	+2	−3	−5	−9	−10	−7	−4	−2	−1	0	0	0	+2	+3	+4	+4	+4	+3
Means	+3	+3	+3	+3	+3	+3	+5	+3	−1	−5	−6	−10	−8	−5	−3	−1	0	+1	+1	+2	+3	+3	+4	+4	+4

NOTE.—When the sign is + the V. F. is more and when − it is less than the mean.

Hourly Means of the Dip as determined at Barrackpore from the selected quiet days in 1910.

N. 30° +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	40·8	40·8	40·8	40·9	40·8	40·8	40·7	40·6	40·5	40·2	39·9	39·4	39·3	39·2	39·2	39·7	40·0	40·4	40·6	40·6	40·7	40·7	40·8	40·7	40·7	40·5
February	41·4	41·4	41·3	41·5	41·2	41·2	41·2	41·1	41·0	40·5	40·0	39·8	39·7	39·8	40·1	40·5	40·7	41·1	41·2	41·2	41·3	41·3	41·4	41·2	41·2	40·9
March	41·4	41·4	41·4	41·4	41·4	41·4	41·3	41·4	41·0	40·2	39·4	38·9	39·1	39·3	39·7	40·2	40·7	40·9	41·1	41·3	41·5	41·5	41·6	41·6	41·5	40·8
October	44·3	44·2	44·2	44·2	44·2	44·1	44·2	44·2	44·0	43·5	43·0	42·4	42·2	42·3	42·8	43·4	43·7	43·6	43·7	43·8	43·9	43·8	43·8	43·8	43·7	43·6
November	44·8	44·7	44·7	44·6	44·5	44·6	44·5	44·3	44·0	43·6	43·1	42·8	42·8	43·2	43·5	43·8	44·0	44·1	44·3	44·6	44·5	44·6	44·4	44·4	44·4	44·1
December	44·1	44·0	44·0	44·0	44·0	44·0	43·9	43·8	43·8	43·4	43·2	42·7	42·4	42·3	42·4	42·8	43·1	43·4	43·6	43·7	43·9	44·0	43·9	44·0	43·8	43·5
Means	42·8	42·8	42·7	42·8	42·7	42·7	42·6	42·6	42·4	41·9	41·4	41·0	40·9	41·0	41·3	41·7	42·0	42·3	42·4	42·5	42·6	42·7	42·7	42·6	42·6	42·2
Summer.																										
April	42·1	42·0	42·1	42·1	42·1	42·1	42·2	42·4	42·1	41·2	40·4	39·9	39·8	40·1	40·8	41·4	41·7	41·9	42·0	42·2	42·1	42·2	42·2	42·2	42·1	41·6
May	42·5	42·4	42·4	42·3	42·3	42·3	42·4	42·1	41·5	40·9	40·7	40·6	40·9	41·0	41·5	41·7	42·1	42·3	42·2	42·3	42·4	42·3	42·3	42·3	42·3	41·9
June	42·5	42·4	42·5	42·4	42·4	42·4	42·6	42·4	42·2	41·7	41·1	40·6	40·8	41·0	41·4	41·7	42·1	42·6	42·7	42·8	42·9	42·8	42·8	42·7	42·7	42·1
July	42·5	42·4	42·5	42·4	42·4	42·4	42·4	42·0	41·8	41·5	41·0	40·7	40·6	40·8	41·1	41·5	41·9	42·2	42·5	42·4	42·6	42·5	42·4	42·4	42·4	42·0
August	43·5	43·6	43·4	43·4	43·4	43·5	43·4	43·2	42·8	42·2	41·9	41·7	41·2	41·4	41·8	42·3	42·6	43·1	43·2	43·3	43·3	43·4	43·5	43·6	43·5	42·9
September	43·4	43·3	43·3	43·3	43·3	43·2	43·3	43·3	43·2	43·1	42·6	42·3	42·5	42·4	42·5	42·6	42·7	42·8	42·9	43·2	43·3	43·4	43·4	43·3	43·3	43·0
Means	42·8	42·7	42·7	42·7	42·7	42·7	42·7	42·6	42·3	41·8	41·3	41·0	41·0	41·1	41·5	41·9	42·2	42·5	42·6	42·7	42·8	42·8	42·8	42·8	42·7	42·3

Diurnal Inequality of the Dip at Barrackpore as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·5	+0·5	+0·5	+0·6	+0·5	+0·5	+0·4	+0·3	+0·2	−0·1	−0·4	−0·9	−1·0	−1·1	−1·1	−0·6	−0·3	+0·1	+0·3	+0·3	+0·4	+0·4	+0·5	+0·4	+0·4
February	+0·5	+0·5	+0·4	+0·6	+0·3	+0·3	+0·3	+0·2	+0·1	−0·4	−0·9	−1·1	−1·2	−1·1	−0·8	−0·4	−0·2	+0·2	+0·3	+0·3	+0·4	+0·4	+0·5	+0·3	+0·3
March	+0·6	+0·6	+0·6	+0·6	+0·6	+0·6	+0·5	+0·6	+0·2	−0·6	−1·4	−1·9	−1·7	−1·5	−1·1	−0·6	−0·1	+0·1	+0·3	+0·5	+0·7	+0·7	+0·8	+0·8	+0·7
October	+0·7	+0·6	+0·6	+0·6	+0·6	+0·5	+0·6	+0·6	+0·4	−0·1	−0·6	−1·2	−1·4	−1·3	−0·8	−0·2	+0·1	0·0	+0·1	+0·2	+0·3	+0·2	+0·2	+0·2	+0·1
November	+0·7	+0·6	+0·6	+0·5	+0·4	+0·5	+0·4	+0·2	−0·1	−0·5	−1·0	−1·3	−1·3	−0·9	−0·6	−0·3	−0·1	0·0	+0·2	+0·5	+0·4	+0·5	+0·3	+0·3	+0·3
December	+0·6	+0·5	+0·5	+0·5	+0·5	+0·5	+0·4	+0·3	+0·3	−0·1	−0·3	−0·8	−1·1	−1·2	−1·1	−0·7	−0·4	−0·1	+0·1	+0·2	+0·4	+0·5	+0·4	+0·5	+0·3
Means	+0·6	+0·6	+0·5	+0·6	+0·5	+0·5	+0·4	+0·4	+0·2	−0·3	−0·8	−1·2	−1·3	−1·2	−0·9	−0·5	−0·2	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·4	+0·4
Summer.																									
April	+0·5	+0·4	+0·5	+0·5	+0·5	+0·5	+0·6	+0·8	+0·5	−0·4	−1·2	−1·7	−1·8	−1·5	−0·8	−0·2	+0·1	+0·3	+0·4	+0·6	+0·5	+0·6	+0·6	+0·6	+0·5
May	+0·6	+0·5	+0·5	+0·4	+0·4	+0·4	+0·5	+0·2	−0·4	−1·0	−1·2	−1·3	−1·0	−0·9	−0·4	−0·2	+0·2	+0·4	+0·3	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4
June	+0·4	+0·3	+0·4	+0·3	+0·3	+0·3	+0·5	+0·3	+0·1	−0·4	−1·0	−1·5	−1·3	−1·1	−0·7	−0·4	0·0	+0·5	+0·6	+0·7	+0·8	+0·7	+0·7	+0·6	+0·6
July	+0·5	+0·4	+0·5	+0·4	+0·4	+0·4	+0·4	+0·0	−0·2	−0·5	−1·0	−1·3	−1·4	−1·2	−0·9	−0·5	−0·1	+0·2	+0·5	+0·4	+0·6	+0·5	+0·5	+0·4	+0·4
August	+0·6	+0·7	+0·5	+0·5	+0·5	+0·6	+0·5	+0·3	−0·1	−0·7	−1·0	−1·2	−1·7	−1·5	−1·1	−0·6	−0·3	+0·2	+0·3	+0·4	+0·4	+0·5	+0·6	+0·7	+0·6
September	+0·4	+0·3	+0·3	+0·3	+0·3	+0·2	+0·3	+0·3	+0·2	+0·1	−0·4	−0·7	−0·5	−0·6	−0·5	−0·4	−0·3	−0·2	−0·1	+0·2	+0·3	+0·4	+0·4	+0·3	+0·3
Means	+0·5	+0·4	+0·4	+0·4	+0·4	+0·4	+0·4	+0·3	0·0	−0·5	−1·0	−1·3	−1·3	−1·2	−0·8	−0·4	−0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·5	+0·5	+0·4

NOTE.—When the sign is + the Dip is more and when − it is less than the mean.

F.—Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Toungoo from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
						·38000						Winter.														
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	772	775	773	775	774	775	777	781	787	793	798	798	799	795	793	787	780	777	776	776	776	776	775	776	776	782
February .	773	774	774	773	776	778	779	783	791	798	804	803	805	801	794	786	780	774	773	777	776	774	775	777	776	783
March .	786	782	783	787	787	785	787	788	796	807	819	825	822	814	805	796	788	787	787	786	783	781	780	781	781	793
October .	787	788	791	788	790	791	789	789	794	806	815	824	826	824	814	803	796	796	796	798	794	795	796	797	797	799
November .	802	804	807	808	809	809	811	816	822	828	835	839	837	832	822	817	813	810	808	805	803	804	807	810	806	815
December .	823	822	824	824	825	825	827	832	836	841	847	854	858	851	846	843	839	838	831	828	826	823	824	823	830	834
Means	791	791	792	793	794	794	795	798	804	812	820	824	825	820	812	805	799	797	795	795	793	792	793	794	794	801
												Summer.														
April . .	777	778	778	780	779	779	780	778	782	799	814	820	820	815	804	791	785	781	781	780	780	779	780	782	782	788
May . .	785	786	786	788	789	790	789	792	799	812	821	822	821	813	805	798	789	785	788	790	789	790	790	789	790	796
June . .	793	791	791	791	793	792	794	793	798	806	817	823	824	820	812	803	793	783	781	785	782	784	790	788	791	797
July . .	800	800	801	802	801	803	804	809	813	819	826	830	831	829	822	813	806	800	799	801	801	801	803	803	804	809
August .	797	796	796	797	797	798	801	805	809	816	825	835	834	833	828	821	813	806	800	803	804	805	805	803	801	809
September .	807	809	813	808	807	809	809	807	805	810	813	820	815	820	820	816	815	809	811	810	808	807	807	809	810	811
Means .	793	793	794	794	794	795	796	797	801	810	819	825	824	822	815	807	800	794	793	795	794	794	796	796	796	802

Diurnal Inequality of the Horizontal Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
													Winter.												
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−10	−7	−9	−7	−8	−7	−5	−1	+5	+11	+16	+16	+17	+13	+11	+5	−2	−5	−6	−6	−6	−6	−7	−6	−6
February . .	−10	−9	−9	−10	−7	−5	−4	0	+8	+15	+21	+20	+22	+18	+11	+3	−3	−9	−10	−6	−7	−9	−8	−6	−7
March . .	−7	−11	−10	−6	−6	−8	−6	−5	+3	+14	+26	+32	+29	+21	+12	+8	−5	−6	−6	−7	−10	−12	−13	−12	−12
October . .	−12	−11	−8	−11	−9	−8	−10	−10	−5	+7	+16	+25	+27	+25	+15	+4	−3	−3	−3	−1	−5	−4	−3	−2	−2
November . .	−13	−11	−8	−7	−6	−6	−4	+1	+7	+13	+20	+24	+22	+17	+7	+2	−2	−5	−7	−10	−12	−11	−8	−5	−9
December . .	−11	−12	−10	−10	−9	−9	−7	−2	+2	+7	+13	+20	+24	+17	+12	+9	+5	+4	−3	−6	−8	−11	−10	−11	−4
Means . .	−10	−10	−9	−8	−7	−7	−6	−3	+3	+11	+19	+23	+24	+19	+11	+4	−2	−4	−6	−6	−8	−9	−8	−7	−7
													Summer.												
April . .	−11	−10	−10	−8	−9	−9	−8	−10	−6	+11	+26	+32	+32	+27	+16	+3	−3	−7	−7	−8	−8	−9	−8	−6	−6
May . .	−11	−10	−10	−8	−7	−6	−7	−4	+3	+16	+25	+26	+25	+17	+9	+2	−7	−11	−8	−6	−7	−6	−6	−7	−6
June . .	−4	−6	−6	−6	−4	−5	−3	−4	+1	+9	+20	+26	+27	+23	+15	+6	−4	−14	−16	−12	−15	−13	−7	−9	−6
July . .	−9	−9	−8	−7	−8	−6	−5	0	+4	+10	+17	+21	+22	+20	+13	+4	−3	−9	−10	−8	−8	−8	−6	−6	−5
August . .	−12	−13	−13	−12	−12	−11	−8	−4	0	+7	+16	+26	+25	+24	+19	+12	+4	−3	−9	−6	−5	−4	−4	−6	−8
September . .	−4	−2	+2	−3	−4	−2	−2	−4	−6	−1	+2	+9	+4	+9	+9	+5	+4	−2	0	−1	−3	−4	−4	−2	−1
Means . .	−9	−9	−8	−8	−8	−7	−6	−5	−1	+8	+17	+23	+22	+20	+13	+5	−2	−8	−9	−7	−8	−8	−6	−6	−6

Hourly Means of the Declination as determined at Toungoo from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Mns.
							E 0° +					Winter.														
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	27·3	27·2	27·2	27·0	27·0	26·9	26·6	26·5	27·2	28·4	29·2	28·9	28·0	27·4	26·8	26·4	27·0	27·3	27·4	27·4	27·3	27·3	27·3	27·3	27·3	27·3
February .	26·8	26·9	27·0	27·0	26·9	26·7	26·4	26·5	26·9	27·3	27·2	27·0	26·6	26·8	26·9	27·2	27·3	27·0	26·7	26·9	27·0	26·9	26·9	26·8	26·9	26·9
March .	26·5	26·6	26·6	26·3	26·2	26·1	26·2	27·2	28·1	28·4	27·9	27·0	26·2	25·8	25·9	26·5	26·8	26·8	26·4	26·4	26·4	26·4	26·4	26·5	26·5	26·6
October .	23·3	23·3	23·3	23·4	23·2	23·1	23·4	24·3	24·7	24·6	24·1	23·7	22·8	22·0	22·4	23·2	24·1	24·0	23·1	23·1	23·2	23·3	23·2	23·2	23·2	23·4
November .	23·0	23·0	23·2	22·9	22·9	22·7	22·6	22·5	23·0	23·3	23·4	23·1	22·7	22·8	22·8	22·8	22·9	22·9	22·9	23·0	22·9	22·7	22·7	22·7	22·9	22·9
December .	22·3	22·3	22·2	22·1	22·1	21·9	21·7	21·5	22·1	22·9	23·0	22·9	22·5	22·3	22·1	22·3	22·6	22·8	22·6	22·6	22·4	22·4	22·3	22·3	22·4	22·3
Means .	24·9	24·9	24·9	24·8	24·7	24·6	24·5	24·8	25·3	25·8	25·8	25·4	24·8	24·5	24·5	24·7	25·1	25·1	24·9	24·9	24·9	24·8	24·8	24·8	24·9	24·9
												Summer.														
April .	26·0	26·2	26·2	26·1	26·1	26·0	26·4	27·4	27·7	27·4	26·4	25·1	24·3	24·2	24·5	25·2	25·6	26·1	25·9	25·8	25·6	25·6	25·7	25·8	26·0	25·9
May .	25·6	25·8	26·0	25·9	25·8	25·9	26·7	27·5	27·6	26·9	25·6	24·4	23·8	24·0	24·5	25·0	25·6	25·9	25·5	25·3	25·2	25·2	25·2	25·4	25·6	25·6
June .	25·0	25·4	25·4	25·4	25·5	25·7	27·0	28·3	28·3	27·3	25·8	24·1	23·8	23·1	23·3	23·8	24·6	25·1	25·6	25·1	25·1	24·9	25·0	25·0	25·1	25·3
July .	24·8	24·9	25·0	25·1	25·1	25·2	26·3	27·0	26·9	26·2	25·1	24·2	23·4	3·3	23·5	23·7	24·1	24·5	24·5	24·8	24·3	24·2	24·3	24·4	24·6	24·8
August .	24·1	24·3	24·3	24·4	24·6	24·8	26·0	27·0	27·3	26·0	24·4	22·9	22·3	21·9	22·1	22·7	23·2	24·0	23·9	23·8	23·8	23·8	23·9	24·0	24·1	24·1
September .	23·8	23·9	24·0	24·1	24·1	24·2	25·1	26·2	26·0	24·9	23·4	22·1	21·3	21·1	21·7	22·8	23·7	24·0	23·7	23·6	23·4	23·4	23·5	23·7	23·7	23·6
Means .	24·9	25·1	25·2	25·2	25·2	25·3	26·3	27·2	27·3	26·5	25·1	23·8	23·1	22·9	23·3	23·9	24·5	24·9	24·9	24·7	24·6	24·5	24·6	24·7	24·9	24·9

Diurnal Inequality of the Declination at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	0·0	−0·1	−0·1	−0·3	−0·3	−0·4	−0·7	−0·8	−0·1	+1·1	+1·9	+1·6	+0·7	+0·1	−0·5	−0·9	+0·3	0·0	+0·1	+0·1	0·0	0·0	0·0	0·0	0·0
February	−0·1	0·0	+0·1	+0·1	0·0	−0·2	−0·5	−0·4	0·0	+0·4	+0·3	+0·1	−0·3	−0·1	0·0	+0·3	+0·4	+0·1	−0·2	0·0	+0·1	0·0	0·0	−0·1	0·0
March	−0·1	0·0	0·0	−0·3	−0·4	−0·5	−0·4	+0·6	+1·5	+1·8	+1·3	+0·4	−0·4	−0·8	−0·7	−0·1	+0·2	+0·2	−0·2	−0·2	−0·2	−0·2	−0·2	−0·1	−0·1
October	−0·1	−0·1	−0·1	0·0	−0·2	−0·3	0·0	+0·9	+1·3	+1·2	+0·7	+0·3	−0·6	−1·4	−1·0	−0·2	+0·7	+0·6	−0·3	−0·3	−0·2	−0·1	−0·2	−0·2	−0·2
November	+0·1	+0·1	+0·3	0·0	0·0	−0·2	−0·3	−0·4	+0·1	+0·4	+0·5	+0·2	−0·2	−0·1	−0·1	−0·1	0·0	0·0	0·0	+0·1	0·0	−0·2	−0·2	−0·2	0·0
December	0·0	0·0	−0·1	−0·2	−0·2	−0·4	−0·6	−0·8	−0·2	+0·6	+0·7	+0·6	+0·2	0·0	−0·2	0·0	+0·3	+0·5	+0·3	+0·3	+0·1	+0·1	0·0	0·0	+0·1
Means	0·0	0·0	0·0	−0·1	−0·2	−0·3	−0·4	−0·1	+0·4	+0·9	+0·9	+0·5	−0·1	−0·4	−0·4	−0·2	+0·2	+0·2	0·0	0·0	0·0	−0·1	−0·1	−0·1	0·0
Summer.																									
April	+0·1	+0·3	+0·3	+0·2	+0·2	+0·1	+0·5	+1·5	+1·8	+1·5	+0·5	−0·8	−1·6	−1·7	−1·4	−0·7	−0·3	+0·2	0·0	−0·1	−0·3	−0·3	−0·2	−0·1	+0·1
May	0·0	+0·2	+0·4	+0·3	+0·2	+0·3	+1·1	+1·9	+2·0	+1·3	0·0	−1·2	−1·8	−1·6	−1·1	−0·6	0·0	+0·3	−0·1	−0·3	−0·4	−0·4	−0·4	−0·2	0·0
June	−0·3	+0·1	+0·1	+0·1	+0·2	+0·4	+1·7	+3·0	+3·0	+2·0	+0·5	−1·2	−2·0	−2·2	−2·0	−1·5	−0·7	−0·2	+0·3	−0·2	−0·2	−0·4	−0·3	−0·3	−0·2
July	0·0	+0·1	+0·2	+0·3	+0·3	+0·4	+1·5	+2·2	+2·1	+1·4	+0·3	−0·6	−1·4	−1·5	−1·3	−1·1	−0·7	−0·3	−0·3	−0·5	−0·5	−0·6	−0·5	−0·4	−0·2
August	0·0	+0·2	+0·2	+0·3	+0·5	+0·7	+1·9	+2·9	+3·2	+1·9	+0·3	−1·2	−1·8	−2·2	−2·0	−1·4	−0·9	−0·1	−0·2	−0·3	−0·3	−0·3	−0·2	−0·1	0·0
September	+0·2	+0·3	+0·4	+0·5	+0·5	+0·6	+1·5	+2·6	+2·4	+1·3	−0·2	−1·5	−2·3	−2·5	−1·9	−0·8	+0·1	+0·4	+0·1	0·0	−0·2	−0·2	−0·1	+0·1	+0·1
Means	0·0	+0·2	+0·3	+0·3	+0·3	+0·4	+1·4	+2·3	+2·4	+1·6	+0·2	−1·1	−1·8	−2·0	−1·6	−1·0	−0·4	0·0	0·0	−0·2	−0·3	−0·4	−0·3	−0·2	0·0

NOTE.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Toungoo from the selected quiet days in 1910.

·16000 C. G. S. +

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	487	487	487	487	487	487	487	486	488	485	479	468	467	**467**	467	475	483	486	486	487	487	487	489	**489**	489	483
February	**493**	492	492	492	491	492	491	491	490	486	481	**477**	479	481	487	490	489	488	489	490	490	492	491	491	491	489
March	493	493	492	492	492	492	494	494	488	480	472	**470**	481	484	491	494	496	495	496	498	499	500	500	**500**	500	491
October	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Means	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Summer.																										
April	504	504	504	503	503	503	**507**	508	498	490	483	**481**	483	489	498	502	504	503	501	501	500	502	503	503	503	499
May	501	502	502	501	501	502	**506**	504	499	491	**485**	486	491	498	502	505	505	503	500	500	500	501	502	502	503	500
June	501	500	500	501	502	502	**506**	506	497	485	480	477	**477**	484	489	494	498	499	498	497	499	499	499	499	499	495
July	508	507	507	507	507	507	**511**	508	504	496	494	493	**488**	492	498	502	502	501	500	500	501	502	502	503	502	502
August	510	510	510	510	510	510	**515**	515	508	496	488	487	**485**	491	496	501	506	508	505	505	507	507	507	507	507	504
September	504	504	504	504	504	505	**510**	508	497	487	482	**480**	488	494	500	507	509	507	505	506	507	509	508	508	508	501
Means	505	505	505	504	505	505	**509**	508	501	491	485	**484**	485	491	497	502	504	504	502	502	502	503	504	504	504	500

Diurnal Inequality of the Vertical Force at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+4	+4	+4	+4	+4	+4	+4	+3	+5	+2	−4	−15	−16	−16	−16	−8	0	+3	+3	+4	+4	+4	+6	+6	+6
February	+4	+3	+3	+3	+2	+3	+2	+2	+1	−3	−8	−12	−10	−8	−2	+1	0	−1	0	+1	+1	+3	+2	+2	+2
March	+2	+2	+1	+1	+1	+1	+3	+3	−3	−11	−19	−21	−10	−7	0	+3	+5	+4	+5	+7	+8	+9	+9	+9	+9
October	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Means	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...
Summer.																									
April	+5	+5	+5	+4	+4	+4	+8	+7	−1	−9	−16	−18	−16	−10	−1	+3	+5	+4	+2	+2	+1	+3	+4	+4	+4
May	+1	+2	+2	+1	+1	+2	+6	+4	−1	−9	−15	−14	−9	−2	+2	+5	+5	+3	0	0	0	+1	+2	+2	+3
June	+6	+5	+5	+6	+7	+7	+11	+11	+2	−10	−15	−18	−18	−11	−6	−1	+3	+4	+3	+2	+4	+4	+4	+4	+4
July	+6	+5	+5	+5	+5	+5	+9	+6	+2	−6	−8	−9	−14	−10	−4	0	0	−1	−2	−2	−1	0	0	+1	0
August	+6	+6	+6	+6	+6	+6	+11	+11	+4	−8	−16	−17	−19	−13	−8	−3	+2	+4	+1	+1	+3	+3	+3	+3	+3
September	+3	+3	+3	+3	+3	+4	+9	+7	−4	−14	−19	−21	−13	−7	−1	+6	+8	+6	+4	+5	+6	+8	+7	+7	+7
Means	+5	+5	+5	+4	+5	+5	+9	+8	+1	−9	−15	−16	−15	−9	−3	+2	+4	+4	+2	+2	+2	+3	+4	+4	+4

NOTE.—When the sign is + the V. F. is greater and when — it is less than the mean.

Hourly Means of the Dip as determined at Toungoo from the selected quiet days in 1910.

N. 22°+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	62·2	62·1	62·2	62·1	62·1	62·1	62·1	61·9	61·8	61·4	60·8	59·9	59·8	59·9	60·0	60·8	61·7	62·0	62·0	62·1	62·1	62·1	62·3	62·2	62·2	61·6
February .	62·6	62·5	62·5	62·5	62·4	62·4	62·3	62·2	61·8	61·3	60·7	60·5	60·5	60·8	61·5	62·0	62·1	62·2	62·3	62·3	62·3	62·5	62·4	62·4	62·4	62·0
March .	62·2	62·3	62·2	62·1	62·1	62·2	62·3	62·2	61·5	60·6	59·6	59·2	60·1	60·6	61·5	62·0	62·4	62·3	62·4	62·6	62·8	62·9	62·9	62·9	62·9	61·8
October .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Means .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Summer.																										
April .	63·3	63·3	63·3	63·1	63·2	63·2	63·5	63·4	62·7	61·6	60·6	60·2	60·4	61·0	62·0	62·7	63·1	63·1	63·0	63·0	62·9	63·1	63·1	63·1	63·1	62·6
May . .	62·9	62·9	62·9	62·7	62·7	62·8	63·1	62·9	62·3	61·2	60·5	60·5	60·9	61·7	62·3	62·7	63·0	63·0	62·7	62·6	62·6	62·7	62·8	62·8	62·8	62·4
June . .	62·6	62·6	62·6	62·7	62·7	62·7	62·9	63·0	62·1	61·0	60·3	59·8	59·8	60·4	61·1	61·7	62·4	62·8	62·7	62·6	62·8	62·7	62·5	62·6	62·5	62·0
July . .	62·9	62·8	62·8	62·8	62·8	62·7	63·0	62·6	62·2	61·4	61·0	60·8	60·4	60·7	61·4	62·0	62·3	62·4	62·3	62·3	62·3	62·4	62·3	62·4	62·3	62·1
August .	63·1	63·2	63·2	63·1	63·1	63·1	63·4	63·3	62·6	61·5	60·6	60·2	60·1	60·6	61·1	61·7	62·3	62·7	62·7	62·6	62·7	62·7	62·7	62·7	62·8	62·3
September .	62·4	62·3	62·2	62·3	62·4	62·4	62·8	62·7	61·9	61·0	60·5	60·1	60·9	61·2	61·6	62·3	62·5	62·5	62·3	62·4	62·6	62·7	62·7	62·6	62·6	62·1
Means .	62·9	62·9	62·8	62·8	62·8	62·8	63·1	63·0	62·3	61·3	60·6	60·3	60·4	60·9	61·6	62·2	62·6	62·8	62·6	62·6	62·7	62·7	62·7	62·7	62·7	62·3

NOTE.—When the sign is + the Dip is more and when — it is less than the mean.

Diurnal Inequality of the Dip at Toungoo as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·6	+0·5	+0·6	+0·5	+0·5	+0·5	+0·5	+0·3	+0·2	−0·2	−0·8	−1·7	−1·8	−1·7	−1·6	−0·8	+0·1	+0·4	+0·4	+0·5	+0·5	+0·5	+0·7	+0·6	+0·6
February	+0·6	+0·5	+0·5	+0·5	+0·4	+0·4	+0·3	+0·2	−0·2	−0·7	−1·3	−1·5	−1·5	−1·2	−0·5	0	+0·1	+0·2	+0·3	+0·3	+0·3	+0·6	+0·4	+0·4	+0·4
March	+0·4	+0·5	+0·4	+0·3	+0·3	+0·4	+0·5	+0·4	−0·3	−1·2	−2·2	−2·6	−1·7	−1·2	−0·3	+0·2	+0·6	+0·5	+0·6	+0·8	+1·0	+1·1	+1·1	+1·1	+1·1
October	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
November	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
December	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Means	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Summer.																									
April	+0·7	+0·7	+0·7	+0·5	+0·6	+0·6	+0·9	+0·8	+0·1	−1·0	−2·0	−2·4	−2·2	−1·6	−0·6	+0·1	+0·5	+0·5	+0·4	+0·4	+0·3	+0·5	+0·5	+0·5	+0·5
May	+0·5	+0·5	+0·5	+0·3	+0·3	+0·4	+0·7	+0·5	−0·1	−1·2	−1·9	−1·9	−1·5	−0·7	−0·1	+0·3	+0·6	+0·6	+0·3	+0·2	+0·2	+0·3	+0·4	+0·4	+0·4
June	+0·6	+0·6	+0·6	+0·7	+0·7	+0·7	+0·9	+1·0	+0·1	−1·0	−1·7	−2·2	−2·2	−1·6	−0·9	−0·3	+0·4	+0·8	+0·7	+0·6	+0·8	+0·7	+0·5	+0·6	+0·5
July	+0·8	+0·7	+0·7	+0·7	+0·6	+0·6	+0·9	+0·5	+0·1	−0·7	−1·1	−1·3	−1·7	−1·4	−0·7	−0·1	+0·2	+0·3	+0·2	+0·2	+0·2	+0·3	+0·2	+0·3	+0·2
August	+0·8	+0·9	+0·9	+0·8	+0·8	+0·8	+1·1	+1·0	+0·3	−0·8	−1·7	−2·1	−2·2	−1·7	−1·2	−0·6	0	+0·4	+0·4	+0·3	+0·4	+0·4	+0·4	+0·5	+0·5
September	+0·3	+0·2	+0·1	+0·2	+0·3	+0·3	+0·7	+0·6	−0·2	−1·1	−1·6	−2·0	−1·2	−0·9	−0·5	+0·2	+0·4	+0·4	+0·2	+0·3	+0·5	+0·6	+0·6	+0·4	+0·5
Means	+0·6	+0·6	+0·5	+0·5	+0·5	+0·5	+0·8	+0·7	0	+1·0	−1·7	−2·0	−1·9	−1·4	−0·7	−0·1	+0·3	+0·5	+0·3	+0·3	+0·4	+0·4	+0·4	+0·4	+0·4

G.—Hourly Means of Horizontal Force in C. G. S. Units (Corrected for temperature) at Kodaikhānal from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
·37000 C. G. S. +													Winter.													
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	462	462	463	462	462	463	465	471	477	489	508	526	534	534	519	499	481	468	467	468	467	466	465	463	463	481
February .	453	455	454	457	458	457	459	466	478	496	506	511	502	489	470	462	458	462	465	461	459	457	459	457	458	469
March . .	456	461	462	461	461	462	461	469	494	531	557	559	541	509	478	460	458	465	469	464	461	458	457	457	459	480
October .	459	461	460	462	464	462	461	464	485	512	534	539	525	505	484	472	471	475	476	471	468	467	467	466	466	479
November .	474	475	479	480	479	479	483	492	505	520	528	529	521	510	501	497	494	490	484	482	480	481	480	478	478	492
December .	493	496	497	497	497	498	499	501	509	520	536	545	542	542	536	527	521	510	505	501	497	499	493	498	497	511
Means .	466	468	469	470	470	470	471	477	491	511	528	535	528	515	498	486	481	478	478	475	472	471	470	470	470	485
													Summer.													
April . .	453	454	455	455	455	456	449	457	480	514	537	547	537	508	475	457	454	458	462	461	459	458	459	459	460	473
May . .	468	468	469	470	469	469	468	474	495	514	526	532	523	508	490	474	471	474	475	473	472	472	472	471	473	483
June . .	469	467	471	472	471	469	469	473	485	503	522	540	538	527	503	482	460	455	459	461	462	468	465	467	468	482
July . .	474	475	476	476	475	475	479	482	490	502	509	513	512	500	486	479	475	476	479	478	477	478	478	479	481	484
August .	467	468	470	469	469	470	470	472	487	509	530	536	533	520	507	494	480	473	475	474	473	472	469	468	478	486
September .	478	481	478	478	480	479	479	486	506	527	542	542	535	521	505	491	481	481	485	481	479	478	479	478	482	494
Means .	468	469	470	470	470	470	469	474	491	512	528	535	530	514	494	480	470	470	473	471	470	471	470	470	474	484

Diurnal Inequality of the Horizontal Force at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1910 Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January . .	−19	−19	−18	−19	−19	−18	−16	−10	−4	+ 8	+27	+45	+53	+53	+38	+18	0	−13	−14	−13	−14	−15	−16	−18	−18
February . .	−16	−14	−15	−12	−11	−12	−10	− 3	+ 9	+27	+37	+42	+33	+20	+ 1	− 7	−11	−7	−4	−8	−10	−12	−10	−12	−11
March . . .	−24	−19	−18	−19	−19	−18	−19	−11	+14	+51	+77	+79	+61	+29	− 2	−20	−22	−15	−11	−16	−19	−22	−23	−23	−21
October . .	−20	−18	−19	−17	−15	−17	−18	−15	+ 6	+33	+55	+60	+46	+26	+ 5	− 7	− 8	−4	−3	−8	−11	−12	−12	−13	−13
November . .	−18	−17	−13	−12	−13	−13	− 9	0	+13	+28	+36	+37	+29	+18	+ 9	+ 5	+ 2	−2	−8	−10	−12	−11	−12	−14	−14
December . .	−18	−15	−14	−14	−14	−13	−12	−10	− 2	+ 9	+25	+34	+31	+31	+25	+16	+10	−1	−6	−10	−14	−12	−18	−13	−14
Means .	−19	−17	−16	−15	−15	−15	−14	− 8	+ 6	+26	+42	+50	+43	+30	+13	+ 1	− 4	− 7	−7	−10	−13	−14	−15	−15	−15
Summer.																									
April . . .	−20	−19	−18	−18	−18	−17	−24	−16	+ 7	+41	+64	+74	+64	+35	+ 2	−16	−19	−15	−11	−12	−14	−15	−14	−14	−13
May . . .	−15	−15	−14	−13	−14	−14	−15	− 9	+12	+31	+43	+49	+40	+25	+ 7	− 9	−12	− 9	−8	−10	−11	−11	−11	−12	−10
June . . .	−13	−15	−11	−10	−11	−13	−13	− 9	+ 3	+21	+40	+58	+56	+45	+21	0	−22	−27	−23	−21	−20	−14	−17	−15	−14
July . . .	−10	− 9	− 8	− 8	− 9	− 9	− 5	− 2	+ 6	+18	+25	+29	+28	+16	+ 2	− 5	− 9	− 8	−5	−6	−7	−6	−6	−5	−3
August . . .	−19	−18	−16	−17	−17	−16	−16	−14	+ 1	+23	+44	+50	+47	+34	+21	+ 8	− 6	−13	−11	−12	−13	−14	−17	−18	−8
September . .	−16	−13	−16	−16	−14	−15	−15	− 8	+12	+33	+48	+48	+41	+27	+11	− 3	−13	−13	−9	−13	−15	−16	−15	−16	−12
Means .	−16	−15	−14	−14	−14	−14	−15	−10	+ 7	+28	+44	+51	+46	+30	+10	− 4	−14	−14	−11	−13	−14	−13	−14	−14	−10

Hourly Means of the Declination as determined at Kodaikānal from the selected quiet days in 1910.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
W 0°+													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	52·6	52·6	52·7	52·8	52·8	53·0	53·2	53·5	53·3	52·2	51·6	51·6	51·7	51·9	52·2	52·3	52·4	52·4	52·5	52·5	52·5	52·5	52·5	52·6	52·6	52·5
February .	53·1	53·0	53·0	53·0	53·1	53·3	53·5	53·6	53·6	53·3	53·1	53·2	53·1	52·9	52·5	52·4	52·3	52·6	53·1	53·0	52·9	53·0	53·0	53·0	52·9	53·0
March .	53·3	53·3	53·4	53·5	53·6	53·6	53·5	53·2	52·9	52·8	52·8	53·0	53·5	53·4	53·2	52·7	52·7	53·0	53·4	53·6	53·6	53·5	53·5	53·4	53·4	53·3
October .	56·2	56·3	56·1	56·2	56·3	56·4	56·1	55·5	55·4	56·1	56·5	56·9	57·1	57·1	56·7	56·0	55·7	55·8	56·1	56·2	56·2	56·2	56·3	56·3	56·1	56·2
November .	56·9	57·1	57·2	57·2	57·5	57·4	57·8	58·0	57·5	57·2	57·3	57·4	57·4	57·1	56·8	57·0	56·9	56·9	57·0	57·0	57·0	57·1	57·1	57·2	57·1	57·2
December .	57·4	57·4	57·5	57·7	57·8	57·9	58·0	58·2	57·8	57·3	57·5	57·8	57·5	57·4	57·4	57·1	57·0	56·8	57·0	57·1	57·2	57·3	57·4	57·4	57·4	57·4
Means .	54·9	55·0	55·0	55·1	55·2	55·3	55·4	55·3	55·1	54·8	54·8	55·0	55·1	55·0	54·8	54·6	54·5	54·6	54·9	54·9	54·9	54·9	55·0	55·0	54·9	54·9
													Summer.													
April .	54·0	54·0	54·0	54·0	54·0	54·1	53·8	52·9	52·8	53·3	53·9	54·2	55·3	55·4	55·2	54·7	54·4	54·2	54·2	54·3	54·4	54·4	54·2	54·1	54·0	54·2
May .	54·4	54·3	54·3	54·3	54·4	54·3	54·0	53·2	53·3	54·2	55·3	56·0	56·5	56·0	55·4	54·8	54·3	54·3	54·6	54·8	54·9	55·0	54·8	54·6	54·5	54·7
June .	54·9	54·8	54·7	54·6	54·7	54·6	53·9	52·8	52·9	53·9	54·8	55·4	56·7	57·0	56·7	56·0	55·4	54·8	54·8	55·1	55·3	55·2	55·2	55·1	55·1	55·0
July .	55·1	55·0	55·0	55·0	54·9	54·8	54·3	53·8	53·8	54·3	55·3	56·0	56·7	56·7	56·2	55·6	55·2	55·1	55·4	55·7	55·8	55·7	55·7	55·4	55·3	55·3
August .	55·7	55·6	55·5	55·3	55·3	55·2	54·7	53·6	53·7	54·4	55·9	57·2	57·7	57·8	57·4	56·7	56·0	55·8	55·6	55·9	55·9	55·9	55·9	55·9	55·9	55·7
September .	55·9	55·7	55·7	55·6	55·6	55·5	54·9	53·9	54·1	55·0	55·9	57·2	57·9	57·9	57·3	56·4	55·6	55·5	55·7	56·0	56·2	56·2	56·0	55·9	55·9	55·9
Means .	55·0	54·9	54·9	54·8	54·8	54·8	54·3	53·4	53·4	54·2	55·2	56·0	56·8	56·8	56·4	55·7	55·2	55·0	55·1	55·3	55·4	55·4	55·3	55·2	55·1	55·1

Diurnal Inequality of the Declination at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
1910. Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	−0·1	−0·1	−0·2	−0·3	−0·3	−0·5	−0·7	−1·0	−0·8	+0·3	+0·9	+0·9	+0·8	+0·6	+0·3	+0·2	+0·1	+0·1	0	0	0	0	0	−0·1	−0·1
February	−0·1	0	0	0	−0·1	−0·3	−0·5	−0·6	−0·6	−0·3	−0·1	−0·2	−0·1	+0·1	+0·5	+0·6	+0·7	+0·4	−0·1	0	+0·1	0	0	0	+0·1
March	0	0	−0·1	−0·2	−0·3	−0·3	−0·2	+0·1	+0·4	+0·5	+0·5	+0·3	−0·2	−0·1	+0·1	+0·6	+0·6	+0·3	−0·1	−0·3	−0·3	−0·2	−0·2	−0·1	−0·1
October	0	−0·1	+0·1	0	−0·1	−0·2	+0·1	+0·7	−0·8	+0·1	−0·3	−0·7	−0·9	−0·9	−0·5	+0·2	+0·5	+0·4	+0·1	0	0	0	−0·1	−0·1	+0·1
November	+0·3	+0·1	0	0	−0·3	−0·2	−0·6	−0·8	−0·3	0	−0·1	−0·2	−0·2	+0·1	+0·4	+0·3	+0·3	+0·3	+0·2	+0·2	+0·2	+0·1	+0·1	0	+0·1
December	0	0	−0·1	−0·3	−0·4	−0·5	−0·6	−0·8	−0·4	+0·1	−0·1	−0·4	−0·1	0	0	+0·3	+0·4	+0·6	+0·4	+0·3	+0·2	+0·1	0	0	0
Means	0	−0·1	−0·1	−0·2	−0·3	−0·4	−0·5	−0·4	−0·2	+0·1	+0·1	−0·1	−0·2	−0·1	+0·1	+0·3	+0·4	+0·3	0	0	0	0	−0·1	−0·1	0
Summer.																									
April	+0·2	+0·2	+0·2	+0·2	+0·2	+0·1	+0·4	+1·3	+1·4	+0·9	+0·3	0	−1·1	−1·2	−1·0	−0·5	−0·2	0	0	−0·1	−0·2	−0·2	0	+0·1	+0·2
May	+0·3	+0·4	+0·4	+0·4	+0·3	+0·4	+0·7	+1·5	+1·4	+0·5	−0·6	−1·3	−1·8	−1·3	−0·7	−0·1	+0·4	+0·4	+0·1	−0·1	−0·2	−0·3	−0·1	+0·1	+0·2
June	+0·1	+0·2	+0·3	+0·4	+0·3	+0·4	+1·1	+2·2	+2·1	+1·1	+0·2	−0·4	−1·7	−2·0	−1·7	−1·0	−0·4	+0·2	+0·2	−0·1	−0·3	−0·2	−0·2	−0·1	−0·1
July	+0·2	+0·3	+0·2	+0·3	+0·4	+0·5	+1·0	+1·5	+1·5	+1·0	0	−0·7	−1·4	−1·4	−0·9	−0·3	+0·1	+0·2	−0·1	−0·4	−0·5	−0·4	−0·4	−0·1	0
August	0	+0·1	+0·2	+0·4	+0·4	+0·5	+1·0	+2·1	+2·0	+1·3	−0·2	−1·5	−2·0	−2·1	−1·7	−1·0	−0·3	−0·1	+0·1	−0·2	−0·2	−0·2	−0·2	−0·2	−0·2
September	0	+0·2	+0·2	+0·3	+0·3	+0·4	+1·0	+2·0	+1·8	+0·9	0	−1·3	−2·0	−2·0	−1·4	−0·5	+0·3	+0·4	+0·2	−0·1	−0·3	−0·3	−0·1	0	0
Means	+0·1	+0·2	+0·2	+0·3	+0·3	+0·3	+0·8	+1·7	+1·7	+0·9	−0·1	−0·9	−1·7	−1·7	−1·3	−0·6	−0·1	+0·1	0	−0·2	−0·3	−0·3	−0·2	−0·1	0

N.B.—When the sign is + the magnet points to the East, and when — to the West of the mean position.

Hourly Means of Vertical Force in C. G. S. Units (Corrected for temperature) at Kodaikānal from the selected quiet days in 1910.

·0200 C. G. S.+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
Winter.																										
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January .	427	427	428	427	427	427	427	427	430	427	422	420	413	403	402	406	411	417	432	424	426	426	427	427	428	422
February .	438	439	438	440	439	438	438	437	436	437	431	426	427	430	432	435	433	430	433	434	435	435	437	437	437	435
March .	444	446	446	446	445	447	448	447	446	439	428	418	417	422	431	439	441	441	439	440	441	442	443	446	446	439
October .	485	485	485	484	485	485	487	487	484	477	473	469	471	474	476	479	481	481	481	481	482	483	485	484	486	481
November .	486	486	488	487	486	487	487	486	489	486	485	487	487	484	481	481	483	484	485	486	487	483	488	489	489	486
December .	492	493	492	491	492	492	492	492	492	490	485	485	485	485	482	481	486	488	490	490	491	494	492	495	495	489
Means .	462	463	463	463	462	463	463	463	463	459	454	451	450	450	451	454	456	457	458	459	460	461	462	463	464	459
Summer.																										
April .	448	448	448	447	448	448	450	451	446	439	432	424	420	420	426	433	445	446	445	445	445	447	448	449	449	443
May .	450	450	450	450	450	451	454	454	448	440	431	431	429	433	439	445	449	450	449	450	451	452	453	453	455	446
June .	464	464	465	464	463	466	470	471	467	461	457	442	437	440	446	446	453	460	460	459	460	462	462	461	462	458
July .	469	468	468	468	468	469	471	470	468	465	464	463	463	465	467	470	468	465	463	462	463	465	465	465	466	466
August .	479	479	479	479	479	480	484	485	480	473	465	457	458	459	462	463	469	472	470	471	474	474	474	474	478	472
September .	485	485	485	485	485	487	489	483	470	461	455	445	451	460	469	475	480	480	478	478	480	481	483	483	484	476
Means .	466	466	466	466	466	467	470	469	463	457	451	444	443	446	452	456	461	462	461	461	462	464	434	464	466	460

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Diurnal Inequality of the Vertical Force at Kodaikânal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
January	+5	+5	+6	+5	+5	+5	+5	+5	+8	+5	0	−2	−9	−19	−20	−16	−11	−5	0	+2	+4	+4	+5	+5	+6
February	+3	+4	+3	+5	+4	+3	+3	+2	+1	+2	−4	−9	−8	−5	−3	0	−2	−5	−2	−1	0	0	+2	+2	+2
March	+5	+7	+7	+7	+6	+8	+9	+8	+7	0	−11	−21	−22	−17	−8	0	+2	+2	0	+1	+2	+3	+4	+7	+7
October	+4	+4	+4	+3	+4	+4	+6	+6	+3	−4	−8	−12	−10	−7	−5	−2	0	0	0	0	+1	+2	+4	+3	+5
November	0	0	+2	+1	0	+1	+1	0	+3	0	−1	+1	+1	−2	−5	−5	−3	−2	−1	0	+1	+2	+2	+3	+3
December	+3	+4	+3	+2	+3	+3	+3	+3	+3	+1	−4	−4	−4	−4	−7	−8	−3	−1	+1	+1	+2	+5	+3	+6	+6
Means	+3	+4	+4	+4	+3	+4	+4	+4	+4	0	−5	−8	−9	−9	−8	−5	−3	−2	−1	0	+1	+2	+3	+4	+5
Summer.																									
April	+6	+6	+6	+5	+6	+6	+8	+9	+4	−3	−10	−18	−22	−22	−16	−3	+3	+4	+3	+3	+3	+5	+6	+7	+7
May	+4	+4	+4	+4	+4	+5	+8	+8	+2	−6	−15	−15	−17	−13	−7	−1	+3	+4	+3	+4	+5	+6	+7	+7	+9
June	+6	+6	+7	+6	+5	+8	+12	+13	+9	+3	−1	−16	−21	−18	−12	−12	−5	+2	+2	+1	+2	+4	+4	+3	+4
July	+3	+2	+2	+2	+2	+3	+5	+4	+2	−1	−2	−3	−3	−1	+1	+4	+2	−1	−3	−4	−3	−1	−1	−1	0
August	+7	+7	+7	+7	+7	+8	+12	+13	+8	+1	−7	−15	−14	−13	−10	−9	−3	0	−2	−1	+2	+2	+2	+2	+6
September	+9	+9	+9	+9	+9	+11	+13	+7	−6	−15	21	−31	−25	−16	−7	−1	+4	+4	+2	+2	+4	+5	+7	+7	+8
Means	+6	+6	+6	+6	+6	+7	+10	+9	+3	−3	−9	−16	−17	−14	−8	−4	+1	+2	+1	+1	+2	+4	+4	+4	+6

N. B.—When the sign is + the V. F is more and when − it is less than the mean.

Hourly Means of the Dip as determined at Kodaikānal from the selected quiet days in 1910.

N 3°+

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.	Means.
													Winter.													
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January .	42·4	42·4	42·5	42·4	42·4	42·4	42·4	42·4	42·6	42·3	41·7	41·4	40·7	39·8	39·8	40·3	40·8	41·5	41·9	42·1	42·3	42·3	42·4	42·4	42·5	41·8
February .	43·5	43·6	43·5	43·6	43·5	43·4	43·4	43·3	43·1	43·1	42·5	42·0	42·2	42·5	42·8	43·1	43·0	42·7	42·9	43·1	43·2	43·2	43·3	43·4	43·4	43·1
March .	44·0	44·2	44·2	44·2	44·1	44·2	44·3	44·2	44·0	43·1	41·9	41·0	41·0	41·7	42·7	43·5	43·7	43·7	43·5	43·6	43·7	43·8	43·9	44·2	44·2	43·4
October .	47·7	47·7	47·7	47·6	47·7	47·7	47·9	47·9	47·5	46·7	46·2	45·8	46·1	46·4	46·8	47·1	47·3	47·3	47·3	47·3	47·4	47·5	47·7	47·6	47·8	47·2
November .	47·7	47·7	47·9	47·8	47·7	47·8	47·8	47·6	47·8	47·5	47·3	47·5	47·5	47·3	47·1	47·1	47·3	47·4	47·6	47·7	47·8	47·9	47·9	48·0	48·0	47·6
December .	48·2	48·2	48·1	48·0	48·1	48·1	48·1	48·1	48·1	47·8	47·3	47·2	47·2	47·2	47·0	47·0	47·4	47·7	47·9	47·9	48·0	48·3	48·2	48·4	48·4	47·8
Means .	45·6	45·6	45·7	45·6	45·6	45·6	45·7	45·6	45·5	45·1	44·5	44·2	44·1	44·2	44·4	44·7	44·9	45·1	45·2	45·3	45·4	45·5	45·6	45·7	45·7	45·2
													Summer.													
April .	44·4	44·4	44·4	44·3	44·4	44·4	44·6	44·6	44·0	43·2	42·4	41·6	41·3	41·5	42·2	43·5	44·1	44·2	44·1	44·1	44·1	44·3	44·3	44·4	44·4	43·7
May .	44·5	44·5	44·5	44·5	44·5	44·6	44·8	44·8	44·1	43·3	42·4	42·4	42·2	42·7	43·3	44·0	44·4	44·4	44·3	44·5	44·5	44·6	44·7	44·7	44·9	44·1
June .	45·8	45·8	45·8	45·7	45·6	45·9	46·3	46·4	45·9	45·3	44·8	43·3	42·9	43·2	43·9	44·0	44·8	45·5	45·4	45·3	45·1	45·6	45·6	45·5	45·6	45·2
July .	46·2	46·1	46·1	46·1	46·1	46·2	46·3	46·2	46·0	45·7	45·5	45·4	45·4	45·7	45·9	46·2	46·1	45·8	45·6	45·5	45·6	45·8	45·8	45·8	45·9	45·9
August .	47·1	47·1	47·1	47·1	47·1	47·2	47·6	47·7	47·1	46·3	45·5	44·7	44·8	45·0	45·3	45·5	46·1	46·5	46·3	46·4	46·6	46·6	46·7	46·7	47·0	46·4
September .	47·6	47·6	47·6	47·6	47·6	47·8	48·0	47·4	46·1	45·1	44·5	43·6	44·2	45·1	46·0	46·6	47·1	47·1	46·9	47·0	47·2	47·3	47·4	47·4	47·5	46·7
Means .	45·9	45·9	45·9	45·9	45·9	46·0	46·3	46·2	45·5	44·8	44·2	43·5	43·5	43·9	44·4	45·0	45·4	45·6	45·4	45·5	45·6	45·7	45·8	45·8	45·9	45·3

Diurnal Inequality of the Dip at Kodaikānal as deduced from the preceding Table.

Hours.	Mid.	1	2	3	4	5	6	7	8	9	10	11	Noon.	13	14	15	16	17	18	19	20	21	22	23	Mid.
Winter.																									
Months.	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
January	+0·6	+0·6	+0·7	+0·6	+0·6	+0·6	+0·6	+0·6	+0·8	+0·5	−0·1	−0·4	−1·1	−2·0	−2·0	−1·5	−1·0	−0·3	+0·1	+0·3	+0·5	+0·5	+0·6	+0·6	+0·7
Febarary	+6·4	+0·5	+0·4	+0·5	+0·4	+0·3	+0·3	+0·2	0	0	−0·6	−1·1	−0·9	−0·6	−0·3	0	−0·1	−0·4	−0·2	0	+0·1	+0·1	+0·2	+0·3	+0·3
March	+0·6	+0·8	+0·8	+0·8	+0·7	+0·8	+0·9	+0·8	+0·6	−0·3	−1·5	−2·4	−2·4	−1·7	−0·7	+0·1	+0·3	+0·3	+0·1	+0·2	+0·3	+0·4	+0·5	+0·8	+0·8
October	+0·5	+0·5	+0·5	+0·4	+0·5	+0·5	+0·7	+0·7	+0·3	−0·5	−1·0	−1·4	−1·1	−0·8	−0·4	−0·1	0	+0·1	+0·1	+0·1	+0·2	+0·3	+0·5	+0·4	+0·6
November	+0·1	+0·1	+0·3	+0·2	+0·1	+0·2	+0·2	0	+0·2	−0·1	−0·3	−0·1	−0·1	−0·3	−0·5	−0·5	−0·3	−0·2	0	+0·1	+0·2	+0·3	+0·3	+0·4	+0·4
December	+0·4	+0·4	+0·3	+0·2	+0·3	+0·3	+0·3	+0·3	+0·3	0	−0·5	−0·6	−0·6	−0·6	−0·8	−0·8	−0·4	−0·1	+0·1	+0·1	+0·2	+0·5	+0·4	+0·6	+0·6
Means	+0·4	+0·4	+0·5	+0·4	+0·4	+0·4	+0·5	+0·4	+0·3	−0·1	−0·7	−1·0	−1·1	−1·0	−0·8	−0·5	−0·3	−0·1	0	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5
Summer.																									
April	+0·7	+0·7	+0·7	+0·6	+0·7	+0·7	+0·9	+0·9	+0·3	−0·5	−1·3	−2·1	−2·4	−2·2	−1·5	−0·2	+0·4	+0·5	+0·4	+0·4	+0·4	+0·6	+0·6	+0·7	+0·7
May	+0·4	+0·4	+0·4	+0·4	+0·4	+0·5	+0·7	+0·7	0	−0·8	−1·7	−1·7	−1·9	−1·4	−0·8	−0·1	+0·3	+0·3	+0·2	+0·4	+0·4	+0·5	+0·6	+0·6	+0·8
June	+0·6	+0·6	+0·6	+0·5	+0·4	+0·7	+1·1	+1·2	+0·7	+0·1	−0·4	−1·9	−2·3	−2·0	−1·3	−1·2	−0·4	+0·3	+0·2	+0·1	+0·2	+0·4	+0·4	+0·3	+0·4
July	+0·3	+0·2	+0·2	+0·2	+0·2	+0·3	+0·4	+0·3	+0·1	−0·2	−0·4	−0·5	−0·5	−0·2	0	+0·3	+0·2	−0·1	−0·3	−0·4	−0·3	−0·1	−0·1	−0·1	0
August	+0·7	+0·7	+0·7	+0·7	+0·7	+0·8	+1·2	+1·3	+0·7	−0·1	−0·9	−1·7	−1·6	−1·4	−1·1	−0·9	−0·3	+0·1	−0·1	0	+0·2	+0·2	+0·3	+0·3	+0·6
September	+0·9	+0·9	+0·9	+0·9	+0·9	+1·1	+1·3	+0·7	−0·6	−1·6	−2·2	−3·1	−2·5	−1·6	−0·7	−0·1	+0·4	+0·4	+0·2	+0·3	+0·5	+0·6	+0·7	+0·7	+0·8
Means	+0·6	+0·6	+0·6	+0·6	+0·6	+0·7	+1·0	+0·9	+0·2	−0·5	−1·1	−1·8	−1·8	−1·4	−0·9	−0·3	+0·1	+0·3	+0·1	+0·2	+0·3	+0·4	+0·5	+0·5	+0·6

PART VII.—REPRODUCING OFFICES.

PHOTO.-LITHO. OFFICE.

BY CAPTAIN A. H. GWYN, I.A.

Photo. Branch.—The out-put of negatives, with the cost per 100 sq. inches for the last three years, is as follows :—

1908-09—2,173,868 sq. in. costing Re. 0-4-9 per 100 sq. in.
1909-10—1,913,889 „ „ „ 0-5-7 „ „
1910-11—1,786,295 „ „ „ 0-6-0 „ „

The decrease in out-put is chiefly in reprints of old standard sheets the stocks of which are now replenished. The old sheets, while twice the size of the modern sheets, required less retouching or 'duffing' than is required for modern sheets in colours.

There has been some increase in the proportion of intricate coloured maps prepared by the method of duffing for colours, to which the higher cost may be ascribed in part ; it is also partly due to the fact that the majority of the staff of negative retouchers were recruited about 1908-09 and received comparatively low pay while under training.

In the studio an "iron base" camera on an iron stand was introduced and proved most successful in combating vibration. The 30″ × 24″ camera was successfully converted by the Mathematical Instrument Office to the same type as the 36″ × 36″.

The preparation "Photopake" has supplanted Indian ink as a duffing medium ; it is more expensive but more efficient.

Mr. Taylor continued his experiments with 'three-colour' blocks, and has obtained further good results, in the direction of increased colour-sensitiveness and higher speed. A set of spectroscopic tests of some well-known commercial dry plates against the office emulsion is in progress.

The process engraving section still suffers from insufficient work. The area of blocks and plates turned out was 9,206 sq. inches, as compared with 15,091 sq. inches in 1909-10 and 10,452 sq. inches in 1908-09. The income of this section exceeded its expenditure by Rs. 1,255.

Litho. Branch.—The out-put of map printing fell off a little. In 1908-09 it was 1,506,607 pulls ; in 1909-10, 1,574,180 and in 1910-11 only 1,383,147 ; no arrears of printing were left over to the next year. One hundred and sixty-four one-inch sheets were printed, as against 239 in 1909-10 ; this accounts for part of the decrease. A flat-bed rubber offset machine has been ordered from England.

General.—The total cost of the office which had been decreasing since 1907-08, when it was Rs. 1,88,966, has risen again slightly. For 1910-11 it has been Rs. 1,64,193, or deducting the pay of non-gazetted officers for September which should rightly fall in 1911-12, Rs. 1,54,639, an increase of Rs. 145 compared with the corresponding figures for 1909-10.

APPENDIX.

LIST OF SURVEY OF INDIA PUBLICATIONS.

Publications marked * can be obtained from the Superintendent, Trigonometrical Surveys, Dehra Dún.
„ „ † „ „ „ the Officer in charge, Map Record & Issue Office, 13, Wood Street, Calcutta.
„ „ ‡ „ „ „ the Officer in charge, Mathematical Instrument Office, 15, Wood Street, Calcutta.
„ „ ¶ „ „ „ the Officer in charge, Surveyor General's Office, 13, Wood Street, Calcutta.
Remaining publications are either out of print or are not available for issue.

ACCOUNT OF THE OPERATIONS OF THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

Price Rupees 10-8 per volume, except where otherwise stated.

Volume I. The Standards of Measure and the Base-Lines, also an Introductory Account of the early Operations of the Survey, during the period of 1800-1830. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Survey.* Dehra Dún, 1870 (out of print).

Do. II. History and General Description of the Principal Triangulation, and of its Reduction. *By Colonel J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Survey, and his Assistants.* Dehra Dún, 1879 (out of print).

Do. III. The Principal Triangulation, the Base-Line Figures, the Karáchi Longitudinal, N. W. Himalaya, and the Great Indus Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dún, 1873 (out of print).

Do. IV. The Principal Triangulation, the Great Arc—Section 24°—30°, Rahún, Gurhágarh and Jogí-Tíla Meridional Series and the Sutlej Series of the North-West Quadrilateral. *By Colonel J. T. Walker, R.E., F.R.S., etc., etc., Superintendent of the Trigonometrical Survey, and his Assistants.* Dehra Dún, 1876.*

Do. IVA. General Description of the Principal Triangulation of the Jodhpore and the Eastern Sind Meridional Series of the North-West Quadrilateral, with the Details of their Reduction and the Final Results. *Prepared in the Office of the Trigonometrical Branch, Survey of India, Colonel C. T. Haig, R.E., Officiating Deputy Surveyor-General, in charge, and published under the orders of Colonel G. C. DePrée, S.C., Surveyor-General of India.* Dehra Dún, 1886.*

Do. V. Details of the Pendulum Operations by Captains J. P. Basevi, R.E., and W. J. Heaviside, R.E., and of their Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dún and Calcutta, 1879.*

Do. VI. The Principal Triangulation of the South-East Quadrilateral, including the Great Arc—Section 18° to 24°, the East Coast Series, the Calcutta and the Bider Longitudinal Series, the Jabalpur and the Biláspur Meridional Series, and the details of their Simultaneous Reduction. *Prepared under the directions of Major-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dún, 1880 (out of print).

Do. VII. General Description of the Principal Triangulation of the Nort-East Quadrilateral, including the Simultaneous Reduction and the Details of five of the component Series, the North-East Longitudinal, the Budhon Meridional, the Rangír Meridional, the Amua Meridional, and the Karára Meridional. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dún, 1882.*

Do. VIII. Details of the Principal Triangulation of eleven of the component Series of the North-East Quadrilateral, including the following Series; the Gurwáni Meridional, the Gora Meridional, the Huríláong Meridional, the Chendwár Meridional, the North Parásnáth Meridional, the North Malúncha Meridional, the Calcutta Meridional, the East Calcutta Longitudinal, the Brahmaputra Meridional, the Eastern Frontier—Section 23° to 26°, and the Assam Longitudinal. *Prepared under the directions of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., etc., etc., Surveyor-General of India and Superintendent of the Trigonometrical Survey.* Dehra Dún, 1882.*

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Do. X. Electro-Telegraphic Longitude Operations executed during the years 1881-82, 1882-83 and 1883-84, by Major G. Strahan, R.E., and Major W. J. Heaviside, R.E. *Prepared under the directions of Colonel C. T. Haig, R.E., Deputy Surveyor-General, Trigonometrical Branch, and published under the orders of Colonel H. R. Thuillier, R.E., Surveyor-General of India.* Dehra Dún, 1887.*

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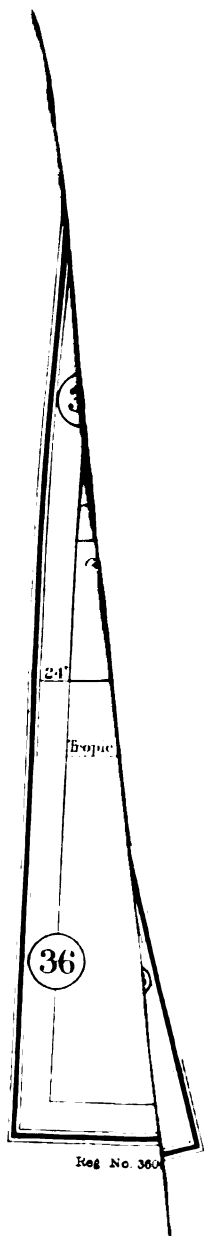
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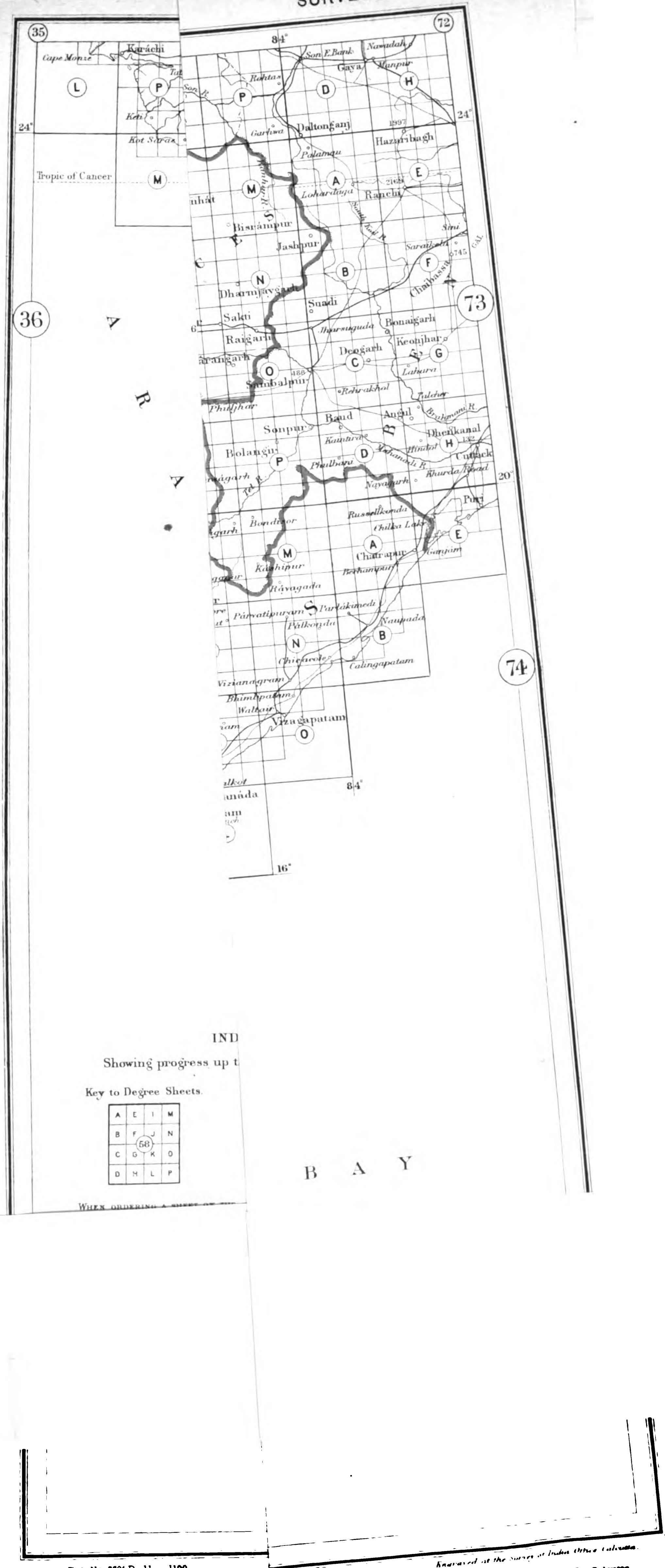
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72
36
73
74
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24°
20°
16°
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Karáchi
Kot Sarai
Tropic of Cancer
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Rohtas
Gaya
Manpur
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Vizagapatam
Kakinada
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B F J N
C G K O
D H L P
58
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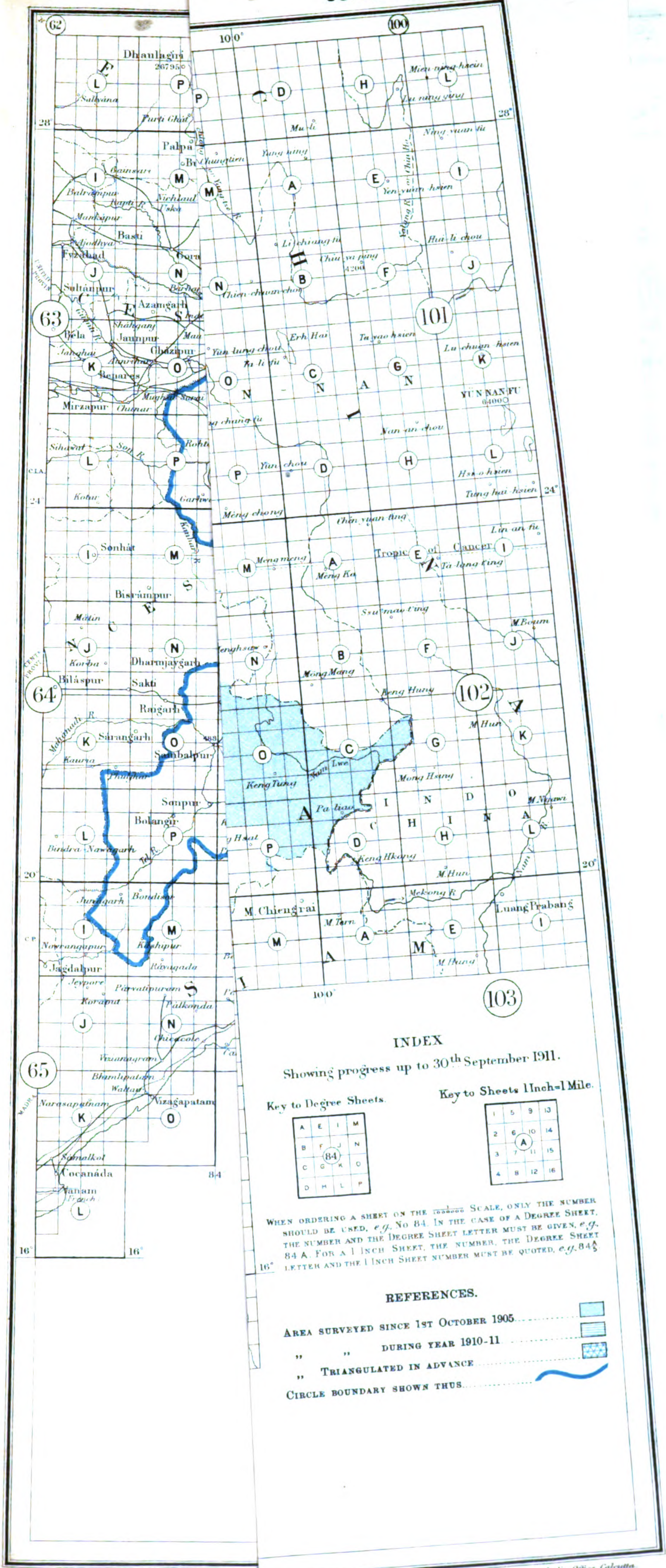
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Circle boundary shown thus
62
63
64
65
100
101
102
103
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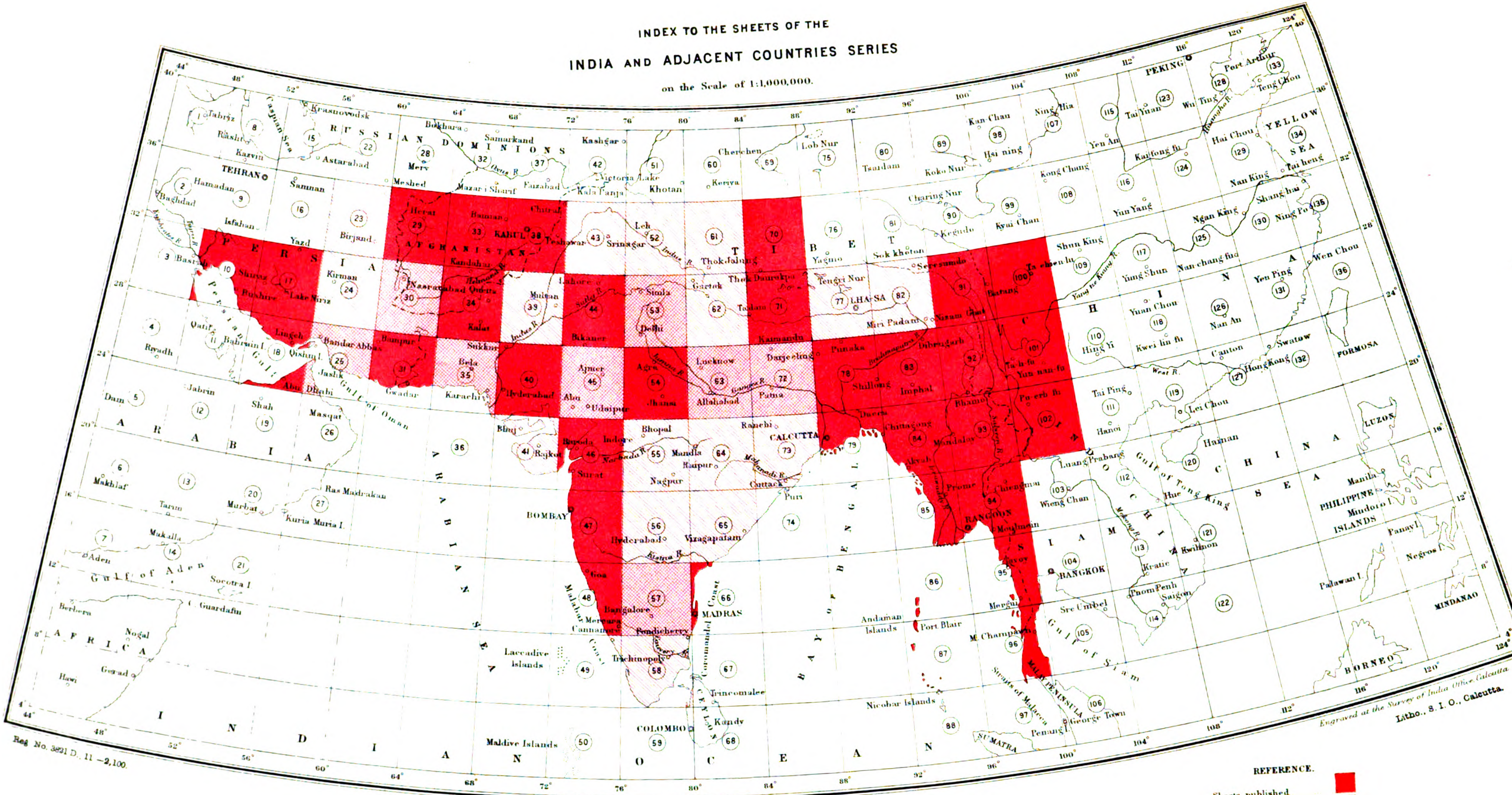

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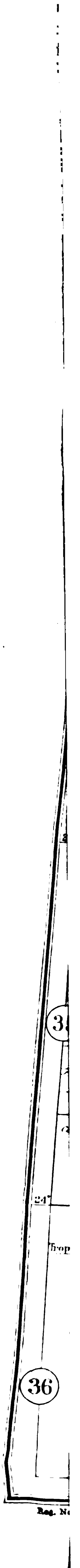
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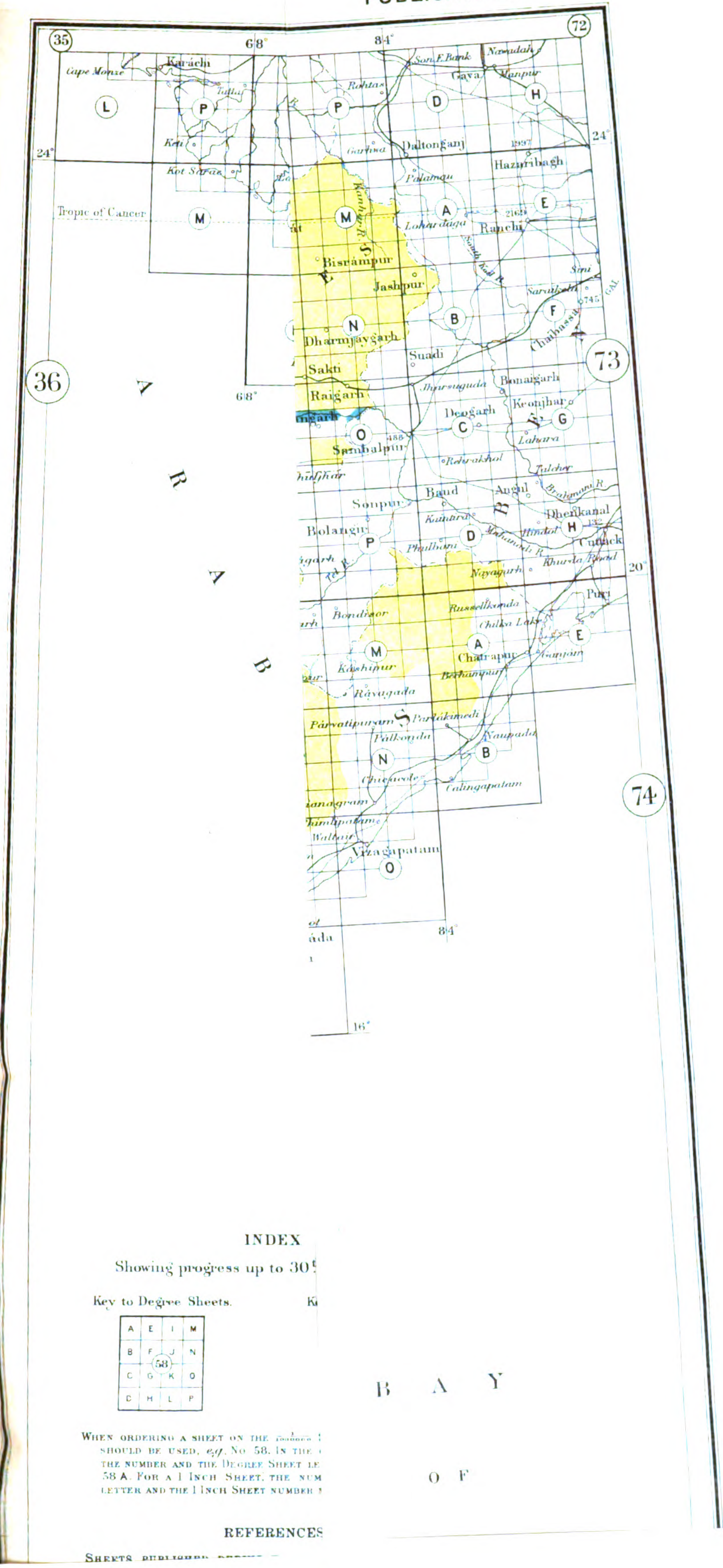

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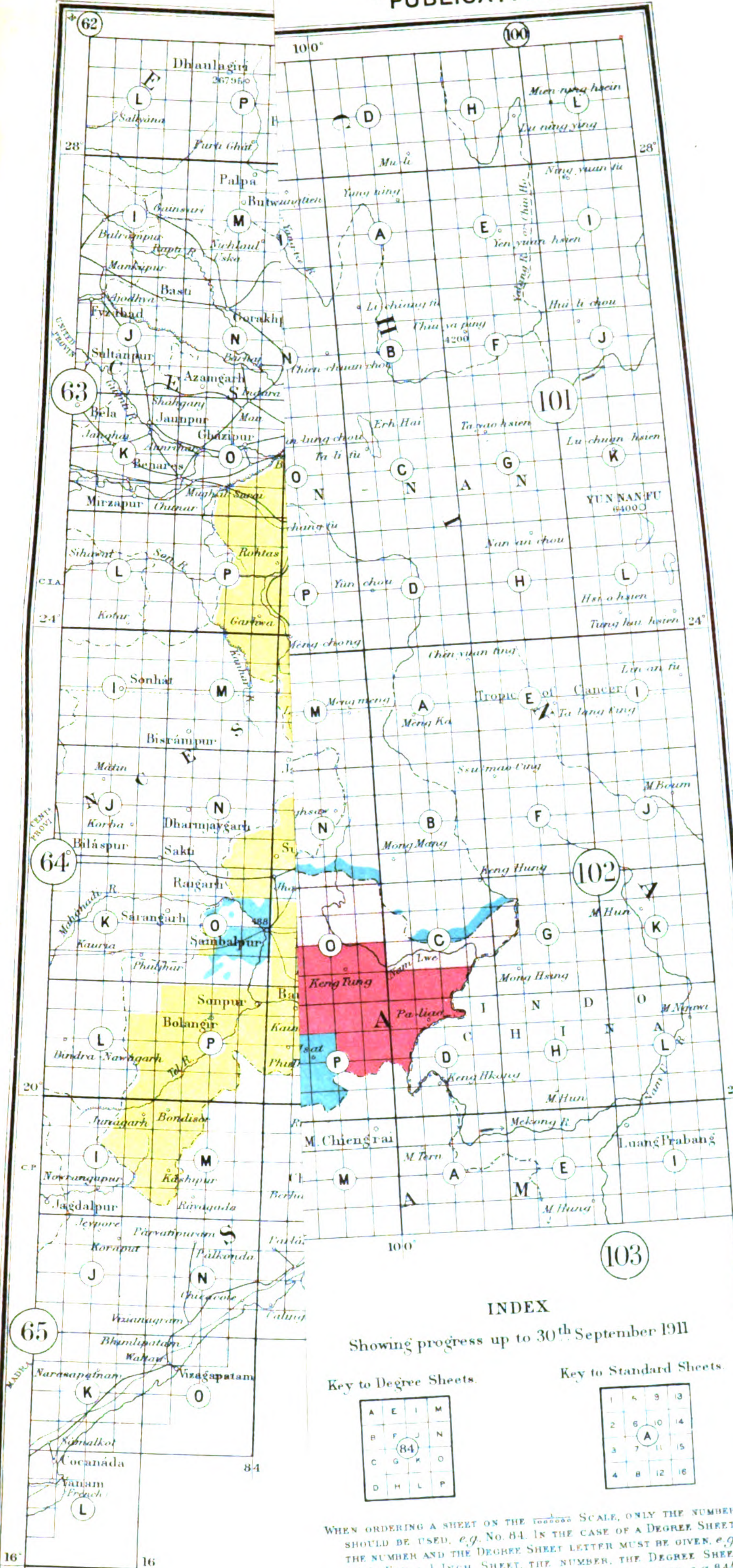

INDEX

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Key to Degree Sheets

A	E	I	M
B	F	J	N
C	G	(84) K	O
D	H	L	P

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1	5	9	13
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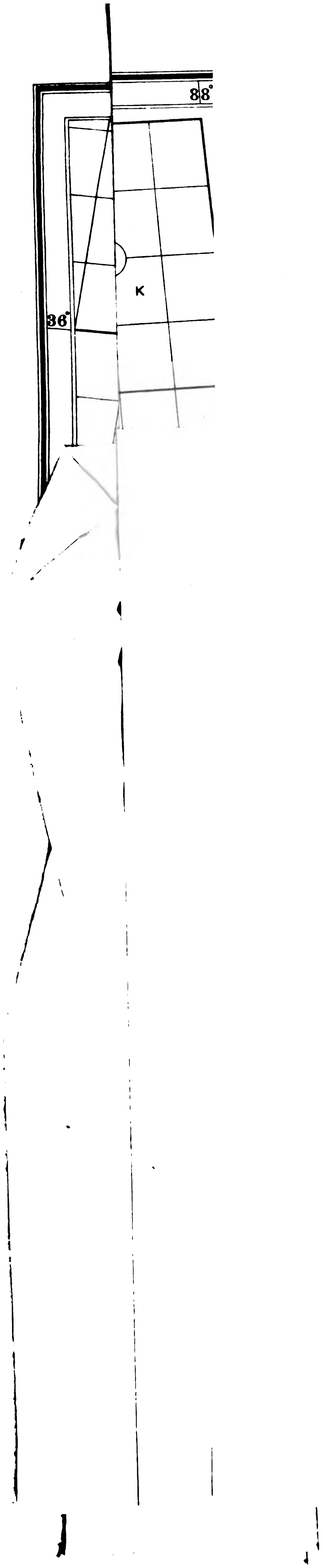
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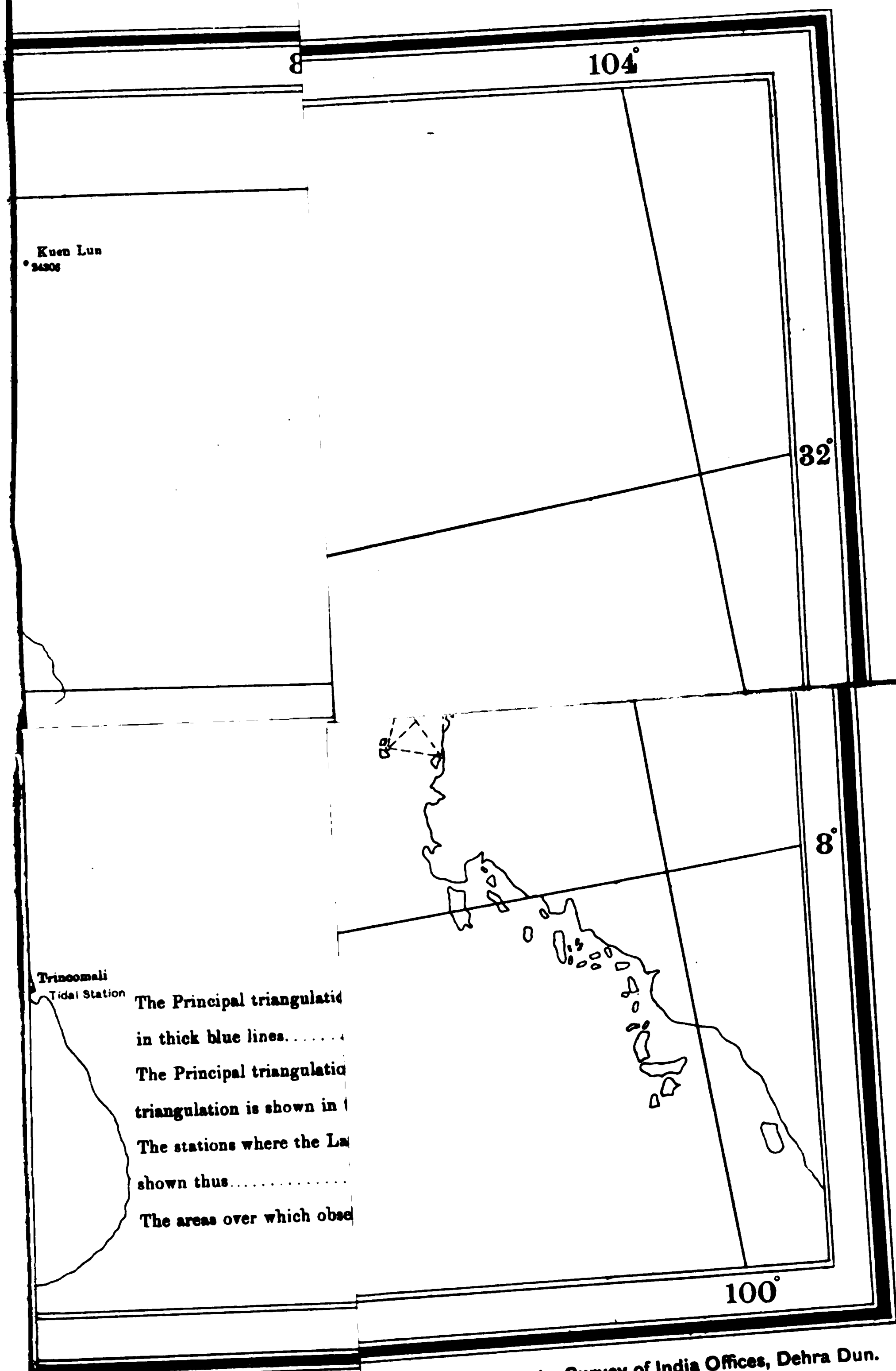

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